JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXI.] FEBRUARY, 1871. [No. 2.

EDITORIAL.

ITEMS AND NOVELTIES.

Illinois and St. Louis Bridge.—In Col. Eads' report we have a full description of the Ice Breakers, which it was found necessary to construct. We infer from it likewise the inference that its construction was coupled with unusual difficulties. He says: "The lateness of the season when the sinking of the east pier commenced, made it absolutely necessary to provide some adequate protection for the requisite boats, machinery, &c., at the site of the pier, against the heavy floating ice which invariably makes its appearance here during the winter.

The freezing over of the river at St. Louis is not, however, an invariable rule, as it does not occur, perhaps, oftener than three in every four years on an average. Last winter was fortunately an exception to the rule. For several days, however, the floating ice was so heavy and compact that it was with the utmost difficulty

that the most powerful steam ferry boats, built expressly to meet such contingencies, could force a passage through it. One or two trips across during an entire day, being all that they could accomplish, frequent attempts in the meantime proving abortive.

To establish in mid-channel any temporary works to withstand an element so apparently resistless, and of such exhaustless volume, was an untried experiment on the Mississippi that presented several very discouraging features. The two chief difficulties were first, to place any construction above the pier that would not be quickly scoured out by the current, and second, to make such construction so strong as to resist the power of the ice to sweep it away."

The difficulty was, nevertheless, after great labor, successfully met by the construction of a triangular system of piles, which were protected from the direct impact of the ice by enormous ice-aprons, which, presenting an inclined surface to the ice, rendered it harmless, the ice sliding up on it, and breaking to pieces, as the soil is treated by the plough-share. This structure, the report further informs us, sufficed to completely turn the ice during winter, and made a thorough protection to the works and barges about the pier.

Triangular Suspension Bridge.—We place before our readers in this issue a plate illustration of the plan of a triangular suspension bridge. The principle involved in this bridge will be readily comprehended by an examination of Figs. 4 and 5. In Fig. 4 P *o o* P′ represents the cable of the usual suspension bridge. B B′ the roadway. When any extra weight is brought upon the bridge at any point as *n*, the roadway at that point is depressed, say to *n′*, the point *p* descending to *p′*, from the points *c* and *d* to each end, the roadway is elevated, between the points it is depressed. The cables tend to the lines P *p′* and P′ *p′*, while the roadway tends to assume the form B *e d n′ c* B′. This variation in the forms of the cable and roadway lines moves from point to point along with the extra weight. To obviate this a heavy truss is generally used. Now, in Fig. 5, if the weight be transmitted in a vertical line to *p*, thence in straight lines to P and P′, there can be no depression. The roadway will remain firm. This principle of transmitting the weight directly and in straight lines to the points of support is the main feature of this bridge. In Fig. 1, P and P′ are tops of piers, W W, &c., main chord of roadway, WS WS, &c., suspending rods or cables, SP and SP′ tower cables. The weight W transmitted

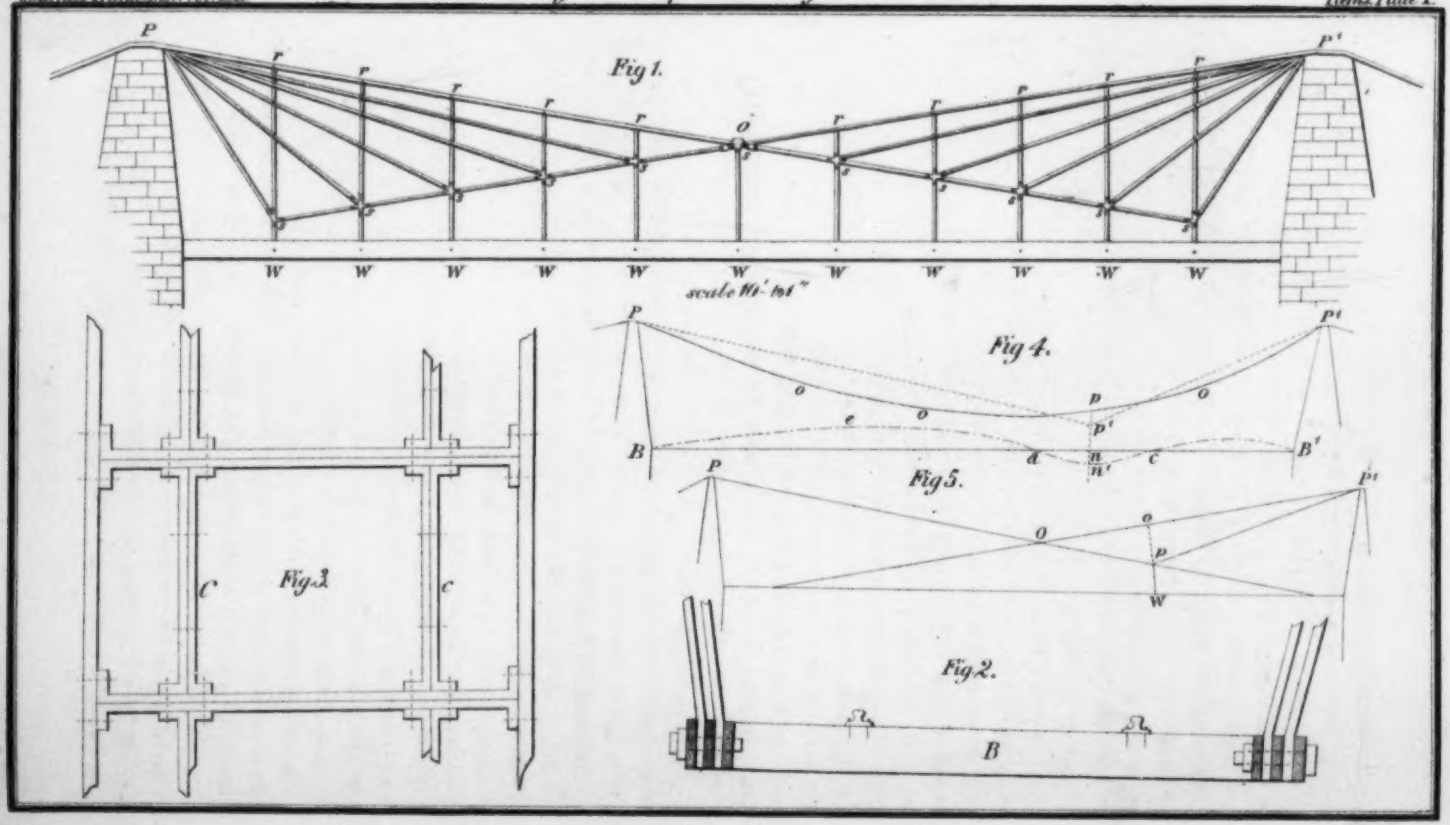


Fig 1.
P
P'
r
o
W
scale 40 ft to 1 in
Fig 3
C
c
Fig 4.
B
B'
Fig 5.
O
p
W
Fig 2.
B

directly to S in each case, thence directly to P and P′. To keep the cables straight the main ones OP and OP′ rest on the top of sustaining rods *r s*, *r s*, &c., to which the minor cables are also attached to keep them straight also. Rails can be laid on the transversal roadway bearers as represented in Fig. 2. B being elevation of the bearers, the rail being represented in section resting thereupon, with supports between as in Fig. 3; *c* and *c* being the plan. With proper horizontal bracing a train of cars could be run over this bridge with safety.

The cables can be made by using steel wire, or parallel flat bars of steel or wrought iron. But it is not intended in this article to indicate any peculiar details of construction.

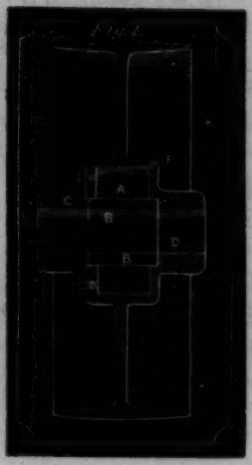
There would be great gain in cases where the main cables could be constructed partly below the roadway, so as to shorten O W as much as possible, thus lessening the angle P O W.

East River Bridge.—The excavations in the caisson of the East River Bridge have lately been progressing through a bed of stiff plastic clay. The accident of a workman having ignited a portion of the wood work—the compressed condition of the air in the chamber supported the combustion with an energy, which placed the ordinary means of its extinguishment out of the question—and seriously imperilled the caisson. The men were, therefore, allowed to ascend, the operation of the compressors suspended and the air within the chamber allowed to return to its normal pressure. It was naturally expected that when this had been effected, the pressure of the water from without would force it beneath the somewhat raised edges of the chamber, and rapidly fill it. To their surprise nothing of the sort occurred; but the chamber remained as free from water as when the compressors were in operation. The plastic and impervious material through which the excavation had been for some time progressing, had packed itself so completely about the outer shell that the water was completely excluded. It was found necessary to extinguish the flames to call into requisition the services of the Brooklyn fire department.

Blowing out Broken Piles.—Four piles driven for the "Cushing Piers" of the Connecticut River Bridge on the Shore Line R. R., during the winter of 1868–9 were broken off by ice, and after trying various plans for drawing them without success, the engineer, Mr. J. Albert Monroe, succeeded in lifting them by driving a 4-inch gas pipe with a solid steel point, well down beside the piles

by means of a sliding ring arrested by a shoulder on the tube, and then introducing a charge of four pounds of powder to the lower end of the pipe and firing it. The piles were at once thrown out by the explosion.

Self-oiling Loose Pulley.—This invention consists of a porous wooden bush, B, secured oil-tight in the chambered hub of a loose pulley. The fast hub, D, is recessed to receive the bush, and the other end of bush is held by the counter hub, C, which is fastened to chamber by bolts.



The bore of hub and bush are the same, and fit the shaft in the ordinary way.

The cavity A is charged with oil through the screw plug hole, F, and there is no escape for it except through the pores of the wood. The more volatile parts of the oil being held in an air-tight cavity, are therefore retained, and the oil is preserved thin and limpid for a great length of time.

This arrangement was patented by J, Goodrich and H. J. Colburn, May 4, 1869, and is shown by Fig. 1.

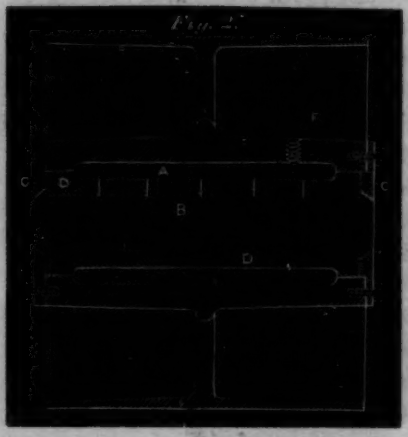


Fig. 2 represents another form of self-oiling loose pulley, the patent of W. W. Crane. June 4, 1867.

In the chambered hub is placed the metallic bush, D, bored through and through to fit the shaft, and fitted tightly at its ends to the bored ends of the pulley hub. To each end is secured a ring, C, with conical central hole.

The oil chamber, A, is filled through the screw plug, F, and reaches the shaft through openings drilled in the bush. J. H. C.

Tinning of Iron, &c.—We append below an account of a process for tinning copper, brass and iron at the ordinary temperature,

and without the assistance of mechanical devices. The paper appears in *Dingler's Polytechnisches Journal*, and is from the pen of F. Stolba, an indefatigable worker in the field of technical chemistry. It is first necessary to thoroughly cleanse the surface to be tinned, which may be accomplished either by the ordinary mechanical process of turning or by chemical means, care being taken to remove any trace of grease.

The efficiency of his plan depends entirely upon a chemical principle, namely, the reduction of a salt of tin, to the metallic state by a more electro-positive metal. The reduced tin is deposited all over the surface to be coated in a highly divided state, and is subsequently made to adhere strongly and to assume a fine polish by friction. The substances employed are finely pulverized zinc and a carefully prepared solution of protochloride of tin (readily formed by treating an excess of tin with hydrochloric acid), to which has been added a trifling amount of bi-tartrate of potassa. The surface to be coated is first entirely moistened with the tin solution, with the aid of a sponge or other suitable material, and directly afterward some of the zinc powder is similarly taken up and rubbed upon it. The tin is reduced by simple substitution. The zinc robbing the tin of its chlorine, and the metal thus separated depositing itself in a state of the finest division all over the surface of the object thus treated. When the tinning is satisfactorily accomplished, the surface is washed with water and finally polished with chalk powder.

A new Lens.—At the last meeting of the Optical Section of the Institute, the feature of the evening was the first exhibition of lens of peculiar combination and construction, designed by a member of the Section, Mr. Jos. Zentmayer, the well-known optician, expressly for use with the gas microscope. The object upon which the designer has bestowed especial care has been to obtain in practice the largest possible aperture with the best equalized field.

In order to meet the case the lenses in the combination are placed in such positions as to transmit the rays as nearly normal as possible to the surface of each member of the group. The performance of the new lens was tested by comparison with that of an excellent Zentmayer lens of the ordinary construction. The power of the new lens was equal to $1\frac{1}{4}'$, with a full aperture of $\frac{1}{8}'$ (a relation which could be expressed by $\frac{f}{1{\cdot}764}$), while the other possessed the same power with $\frac{1}{4}'$ aperture $\left(\frac{f}{8}\right)$. The quantity of light, there-

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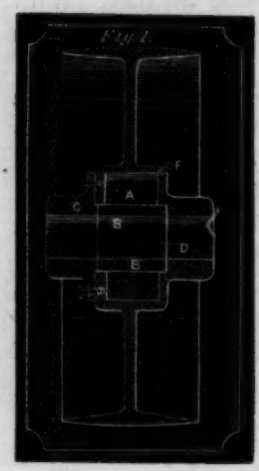

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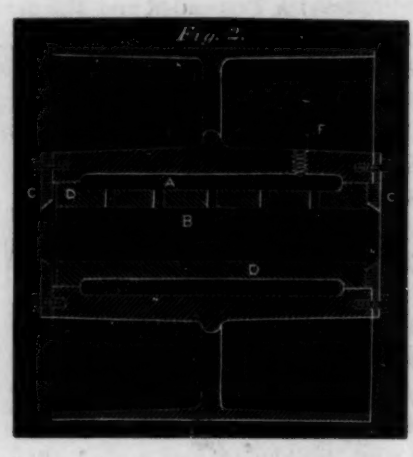

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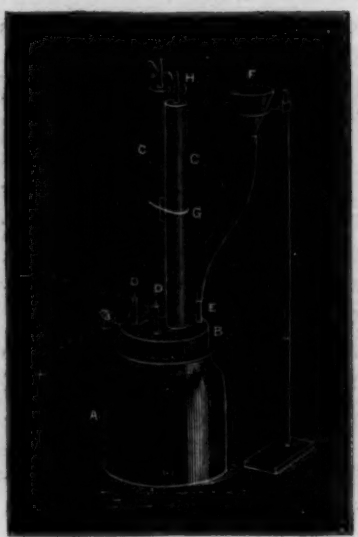
fore, received by the two lenses would be represented by the ratio of 49 : 16 or about 3 : 1. The comparison was instituted with the same objects under the same conditions; the results are therefore reliable, and we are pleased to say fully met the expectations which had been formed of them. The image formed by the new lens possessed nearly, if not quite, three times the brightness of the other, while the deviation from perfect flatness of field was inappreciable.

On a cheap form of Voltaic Decomposition Apparatus.* The decomposition tube devised, I believe, by Dr. Hofman, and described at p. 50 of his "Modern Chemistry," is an extremely elegant and luxurious piece of apparatus for showing analysis of bodies by electricity; but it has two defects, viz: that it is expensive to begin with, and very easily broken, either during its carriage or by the mischances of the laboratory assistant. Experience of the fragile character of these tubes led me to make a more substantial apparatus, which, while it has the advantage of the ordinary tube. can be fitted up in any laboratory for a few shillings. The following is a description of the arrangement:

A is a common pomade bottle, into which is fitted an india-rubber stopper, B, perforated with five holes (two large, two small, and one medium size.) Though the two large holes of the stopper pass two glass tubes, C C, of about ½-inch diameter and 7 or 8 inches length. Each of these tubes is closed at the top by an india-rubber stopper carrying a piece of ⅛-inch glass tube, to which is attached a jet and pinch-cock, H. The electrodes are made as follows:—A piece of thick platinum wire is beaten out at one end to form a flat plate, and is then threaded through a piece of glass tubing rather shorter than itself. When this is done, the glass is melted on to the platinum, and the tube, with its contained wire, is bent in the form of the letter J A second piece of wire and tube is treated similarly to form the



* From the *Chemical News*, communicated by the Editor.

second electrode. When these are made, they are passed through the two small holes of the stopper, B, and project above it, as represented at D D. The electrodes are turned so that they may pass up into the tubes, C C. To the remaining hole of the stopper is fitted a tube, E, connected with a piece of caoutchouc tubing with a funnel, F, supported on the ring of a retort stand. The apparatus is now complete, and when the stopper with its appendages is fitted into the pomade bottle, is all ready for charging. This is done by pouring the acidulated water or other electrolyte into the funnel, F, at the same time opening the pinch-cocks to allow the air to escape. When the bottle and tubes are full, the pinch-cocks are closed, and all is ready for attaching the battery to the electrodes at D D. I omitted to mention that the tubes, C C, may be conveniently steadied, should this be necessary, by tying them against a cork wedge, as represented at G. C. J. WOODWARD, B.Sc.

Compressed Air as a Motor.—In an able paper by Mr. J. F. Haskins, appearing in the *Engineering and Mining Journal*, we glean some interesting statements concerning the history of this subject. Mr. Haskins, who is an earnest advocate of the system, informs us that there exist three plans underlying its utilization as far as the subject has been developed. These are "the water column," "the piston immersed in water," and "the piston simply packed and lubricated by water or other fluids." Of the first class we are informed that there are several varieties, all, in the opinion of the author, containing in them the elements of success.

They operate upon the general plan of starting and stopping a column of water. Those at Mount Cenis are stated to have been very successful and economical. They have small engines actuated by compressed air, which operate the induction and eduction valves. They are placed at an inclination, drawing their supply of water from cisterns, thus insuring clean water. With them they compress air to sixty and seventy pounds to the inch, and sometimes more, as they may require. Other apparatus, depending on a column of water for its power, has been constructed, and there are several parties now experimenting in that direction.

Of the immersed class of compressors we are told that there are also several. They do well for low pressures, but not as well for high ones, the difficulty being that the piston, in moving, has also to move a large body of water, which, of course, absorbs an amount of power equal to its own inertia.

Concerning the vital point of transmission, the opinion is ventured, based upon extensive experience at the Hoosac Tunnel operations, that no difficulty is experienced.

The Naval Observatory Eclipse Party.—The preliminary reports of the observatory party of which, through the courtesy of Prof. J. E. Nourse, we are privileged to placed an early abstract before our readers, indicate a very fair degree of success. It should certainly be a source of sincere gratification to the followers of science in this country to know that two independent observing parties under the patronage and support of two different branches of the government were sent across the ocean in the interest of science. It indicates an intelligent appreciation in the "powers that be" of the sterling value of physical investigation. The observatory expedition is, we believe, mainly composed of the observers of last year's party, under the direction of the Superintendent of Naval Observatory, and detailed by the Secretary of the Navy. From the Coast Survey party, whose organization we mentioned in our January issue, we also have the pleasure of presenting some items of interest.

Facts Relating to the Distinctness of Sound.—The following statistics compiled by Mr. C. R. Moore, at the instance of the Smithsonian Institute, and kindly communicated by him are instructive in showing how the circumstances of locality may vary the distinctions of sound. In the tabulated list of observations which we append, the sounds which furnished the material were the "Sue's" whistle, and the report of the guns at Fortress Monroe. The distinctness of the sound, and the direction and force of the wind were noted, 10 representing the maximum of wind and sound. The point of observations is Prospect Hill. From this locality Fortress Monroe is distant 40 miles in a southwesterly direction. Cherry Stone 13, and Hungar's Wharf 8 miles also S. W. The country between the point of observation and Hungar's Wharf is wooded, and in mild seasons when the trees are in full foliage the sound is almost or entirely lost. The tables from May to October, present sharp lines of demarkation from the remaining months owing to this cause. The curious portion of the table will be found to be in the repeated recurrence of a strong sound, at times reaching even the maximum of distinctness in the teeth of a strong northeasterly wind. Directly the reverse would be expected under ordinary circumstances. Whether or not the country presents any

unusual features, to which this peculiar phenomenon may be referable, does not appear from our correspondent. The fact, however, is mentioned that the sound from Fortress Monroe must cross the Chesapeake Bay.

Prospect Hill, January 9, 1871.

1870.		Sound.	Wind.	Force.
Jan. 1.	Sue's Whistle Hungar's Wharf	8	N. E.	1
	Also at Cherry Stone	4	N. E.	1
6.	Guns at Fortress Monroe	6	S. E.	1
8.	Sue's Whistle at Hungar's	6	N. W.	2
11.	Guns at Fortress Monroe	2	E.	1
17.	Sue's Whistle at Hungar's	8	S. E.	1
22.	" " "	2	S. E.	1
31.	" " "	8	N. E.	2
31.	Guns at Fort Monroe	8	N. E.	2
Feb. 4.	" " "	10	N.	1
17.	" " "	10	N. E.	2
20.	Sue's Whistle at Hungar's	4	S.	2
25.	Guns at Fort Monroe	3	N.	1
26.	Sue's Whistle at Hungar's	5	N.	1
Mar 12.	" " "	4	S. E.	1
Apr. 7.	Guns at Fort Monree	6	N. W.	1
9.	" " "	4	S. W.	1
20.	Sue's Whistle at Hungar's	6	S. W.	1
May 4.	" " "	1	N. W.	1
14.	" " "	1	N.	1
21.	" " "	4	W.	2
23.	Guns at Fort Monroe	1	S. E.	2
Oct. 8.	" " "	3	N. E.	3
10.	" " "	5	S. E.	1
11.	Sue's Whistle at Hungar's	8	S. E.	1
12.	Guns at Fort Monroe	6	N. W.	1
19.	" " "	4	E.	1
25.	" " " and Sue's Whistle	1	S. W.	2
28.	Sue's Whistle at Hungar's	1	N. W.	2
28.	Guns at Fort	6	N. W.	1
Nov. 17.	Sue's Whistle at Hungar's	6	W.	1
19.	" " "	10	N. W.	1
21.	Guns at Fort Monroe	9	N. W.	2
28.	Sue's Whistle at Hungar's	8	N. E.	1
Dec. 3.	" " "	8	N. W.	3
5.	" " " and Guns at Fort	4	S. E.	1
7.	" " "	10	E.	1
10.	" " "	6	N.	1
12.	" " " and Cherry Stone	6	W.	1
17.	" " "	4	W.	1
19.	" " " and Cherry Stone	6	N. E.	1
20.	Guns at Fort	6	N. E.	1
22.	Sue's Whistle at Hungar's	10	N. W.	1
28.	" " "	8	N. E.	1

Journal of the Franklin Institute.—January, 1868.—The demands for sets of the *Journal* have recently been so great as to

cause a serious diminution of the stock on hand. Especially does the management feel the want of the number heading this notice. In view of this fact we are prepared to pay 50 cents for every unmutilated copy of that number which is sent to the Hall of the Institute; and we would respectfully request any of our subscribers who may have a knowledge of the existence and whereabouts of incomplete volumes to aid us in enlarging our stock of the wanting number.

Compressed Leather.—Dr. Dingler.—The author states that offal of leather, cuttings, and scraps, are first cleansed from dirt and dust, then soaked in water containing 1 per cent. of sulphuric acid, until the material becomes soft and plastic, next compressed into the shape of blocks, dried by steam, and lastly rolled out in mills. In order to soften the mass, 1 pound of glycerine is added to 100 pounds of material. The leather thus again obtained is applicable for the inner soles of boots, &c.

Editorial Correspondence.

Jerez, December 23d, 1870.

PROFESSOR MORTON.

DEAR SIR:—By the courtesy of Professor Winlock I am permitted to communicate the general results of our observations of the eclipse. I think I may say that on the whole our expedition has been highly successful, and has fully attained the objects for which it was sent, although perhaps more might have been accomplished had the weather been better. We seem, however, to have been more favored even in this respect than any of the English parties which observed in Spain. I have not yet heard anything from the parties in Algeria and Sicily.

Our party of twelve concentrated at Jerez some 30 miles (by rail) north of Cadiz, about ten days before the eclipse, and although much interrupted by unfavorable weather our instruments were in position and adjustment in good season. Mr. Dean, assisted by Capt. Ernst and Mr. Gannett, had in charge the determination of

our geographical position, using a 46-inch transit, chronometers fitted with galvanic break circuit apparatus, a chronograph, sextant, &c. The photographic apparatus comprised two telescopes equatorially mounted with clockwork, one of 8 inches aperture, and the other of 6, besides a horizontal telescope of 5 inches aperture, and about 30 feet focus, with a plane unsilvered mirror of glass to reflect the sun's rays into the tube. Messrs. Willard, Mahoney and Gannett attended to this department.

Professor Pickering observed for the polarization of the corona with apparatus which I presume he has described in his letter to you. He was assisted by Mr. Ross. Professor Langley also observed for the same, and for the general features and structure of the corona.

We had four spectroscopes in the field. Professor Winlock used an instrument with two prisms. This was attached to an equatorial of 5½ inches aperture which formed a distinct image of the object observed on the slit of the collimator. Mr. Clark assisted him at the finder.

My own instrument was the spectroscope figured and described in a late number of the *Journal*. It was attached to the Dartmouth College Equatoreal of 6½ inches aperture, and like Professor Winlock's, received a distinct image on the slit of the collimator. The observations previous to totality, were made with the whole dispersive power equivalent to 13 prisms. During totality I used 7. As the observations of Professor Pickering last year had made it a matter of interest to observe the general spectrum produced by the total light coming from the moon's immediate neighborhood during totality, without any limitations such as are introduced by throwing an image upon the slit, two instruments were mounted for this purpose. The first consisted of the collimator and telescope of my large 9-prism instrument, with two of its prisms. The telescopes have an aperture of 2¼ inches, and a focal length of about 17, and the prisms are of proportionate size, having, however, an angle of only 45°.

This was mounted upon a board in such a manner that it could have the slit of its collimator readily pointed toward the sun. As its angle of aperture was about 7°, it required no great exactness of direction and no movement during the totality. This instrument was put in charge of Mr. Abbay, a member of one of the English parties, who, at his own request, was kindly detailed to

assist us in the matter, as they had no suitable instrument, and we no spare observer. He brought with him an induction coil and a Geissler tube, prepared under Mr. Lockyer's supervision, which gave the combined spectra of hydrogen, mercury, magnesium and sodium. This spectrum, thrown into the field of view in the ordinary way, formed the scale of reference. Another smaller instrument was fitted up from a star spectroscope of one prism of very dense glass, with telescope and collimator of the usual size—about 1-inch aperture and 7-inch focal length. To increase the light I placed in front of its slit a small telescope, magnifying about 2¼ times, and having a field of 3½°. This was adjusted carefully for distinct vision on a remote object, and its effect was, *not to form an image on the slit* and thus to limit the locality from which the observed spectrum was derived to some small point, but merely *to increase the virtual angular diameter of the sun and the total amount of light received on the slit.* This instrument was put in charge of Mr. Pye, a young Englishman who was spending the winter at Jerez, for the benefit of his health. He had had some experience in spectroscopy, and used his instrument very skilfully and effectively. To all these instruments, excepting Mr. Abbay's, was adapted Professor Winlock's beautiful arrangement for recording the positions of the lines observed. A little chisel is brought down by the simple pressure of the finger, upon a silver plate which moves with the telescope, and thus a fine line is made which permanently marks the position of every line which may be upon the cross-wires of the instrument; these plates are preserved, and afterwards read off at leisure by a suitable micrometer. Besides those I have named, several English gentlemen joined us in general observations, and in making sketches and drawings of the corona. One of these drawings, from the pencil of Mr. Gordon, appeared to me in fidelity and beauty to equal anything I have ever seen,—but I anticipate.

The day and night previous to the eclipse were very fine, but early in the morning it clouded up. When we arose the prospect was very gloomy—it even rained from time to time. We made all our preparations, however, and before the first contact (10·25, A. M., local time) there were many patches of partly clear sky—but there was always, even when clearest, enough haze of frost crystals to cause the sun to be surrounded by a conspicuous halo of 22½° radius.

At the time of the first contact it was clear enough to allow good observations to be made in the usual method. I attempted to use the spectroscope upon it in the same manner as last year, but failed on account of the thin cloud which most of the time entirely obliterated the chromosphere lines.

Between the time of first contact and totality, there were several intervals of moderate clearness, in which photographs of the partial phases were taken. Just before totality the clouds became much thicker and we nearly gave up hope, but at the needed time, almost by the direct interposition of Providence, it would seem, a small rift in the now heavy clouds passed over the sun, and permitted us to see and observe the sublime phenomenon, if not in all the beauty and grandeur of last year, yet satisfactorily and most gratefully.

The details of its structure were not seen this year nearly as well as last by the telescopic observers. The thin cloud shaded out and obliterated definition, without, however, cutting out much light. I think, if anything, it appeared more extensive than then, but much less definite in its outline. Others, however, thought it much less extensive. Its form was, as usual, roughly quadrangular—nearly square; but it is a curious fact that its longest diagonal was neither equatorial nor polar, but made an angle of nearly 45° with the hour circle, lying from the N. W. to the S. E. This was carefully determined by Professor Langley. There was no prominence on the sun's limb which could compare in magnitude and beauty with the "anvil" of last year, but there were many small ones which were very bright and active.

Within 5 minutes after the end of the totality the sky was wholly clouded and we did not see the sun again till just at evening, after a heavy storm of wind and rain. During the totality one good photograph of the corona was obtained with the 6-inch glass, with an exposure of 1½ minutes. It is of course by no means so good as it would have been had the sky been truly clear, but it shows a great deal of detail, curved filaments and radial shadings far better than any before obtained. The picture obtained with the 8-inch glass was nearly injured by not being removed until the sun came out. No attempts were made to photograph the prominences, which can be seen and studied at any time—all efforts were concentrated on the corona.

In respect to the polarization observations, I presume Professor Pickering has fully informed you. It would almost seem that there must have been some peculiar defect in the particular instrument he used last year, as his assistant, Mr. Ross, using the same identical apparatus which Prof. P. did then, obtained the same negative result. But apparently similar instruments used this year, conspired with others quite different in indicating radial polarization of the corona. The appearances in the instruments were much complicated by the cloud and haze, but I believe Prof. Pickering and Prof. Langley both agree that the corona certainly has a considerable proportion of its light radially polarized.

Our spectroscopic results completely confirm those of last year, except that the two faint lines which I saw between D and E last year, and suspected to be corona lines, as well as 1474, were not seen at all this time. 1474 was traced by Professor Winlock to a distance of near 20′ from the sun's limb. I traced it 16′ on the west, 12′ on the north, 14′ on the east, and about 10′ on the south. The principal chromosphere lines were also visible in the corona to a distance of 3′ or 4′. But Prof. W. and myself both agree in attributing these to the reflection of the haze around the sun. I am the more confident as to this, because last year in a clear atmosphere the C line was certainly sharply terminated at the upper limit of the chromosphere or prominence under observation. Mr. Abbay, in his spectroscope, saw only the 1474 line and the F line—the former considerably the brighter of the two. He saw no continuous spectrum.

Mr. Pye saw C (8·5); D_3 (5·5); 1474 (10) and F (3). The numbers appended represent the relative brightness of the lines. All of us, except Mr. Abbay, saw a faint continuous spectrum, but without any traces of dark lines. Still, as far as I am concerned, I should not dare to affirm that there might not have been dark lines without my seeing them, since on account of my using so great dispersive power this spectrum was very faint except when I widened the slit considerably. With the instruments of Prof. W. and Mr. Pye the case is different. I do not think, if dark lines existed, they could have escaped them.

No particular examination was made of the chromosphere spectrum, but I noticed it sufficiently to ascertain that there were probably in it, at least in the particular portion under observation, no lines which I had not already seen under ordinary circumstances.

I saw C, D_1, D_2, D_3, 1474, two or three of the iron lines near E, the four lines of *b*, two Barium lines between *b* and F, and one of the iron lines (often seen there), F, and 2185, which Mr. Lockyer considers a magnesium line. I did not examine the spectrum above this point, nor below C. This was on the eastern limb of the sun, near the point of last internal contact.

Perhaps I may be allowed to interpolate here, that on the previous day I saw in the spectrum a very bright but small prominence on the N. W. limb of the sun, the line below C, which I have seen twice before, but have so often looked for in vain that I had more than half concluded myself to be deceived. It is the reversal of the dark line, 656, of Kirchhoff's map. Also, in the same prominence, and for the first time, I believe, the three *chromium lines* just below *b*. Of course, D_1 and D_2, and all the lines of *b*, were very bright in it, as well as many of the iron lines seldom seen.

But the most interesting spectroscopic observation of the eclipse appears to me to be the ascertaining, at the base of the chromosphere, and, of course, in immediate contact with the photosphere, of a thin layer, in whose spectrum *the dark lines of the ordinary solar spectrum are all reversed.*

Just previous to totality I had carefully adjusted the slit tangential to the sun's limb, at the point where the second contact would take place, and was watching the gradual brightening of 1474 and the magnesium lines. As the crescent grew narrower I noticed a fading out, so to speak, of all the dark lines in the field of view, but was not at all prepared for the beautiful phenomenon which presented itself when the moon finally covered the whole photophere. Then the whole field was at once filled with brilliant lines, which suddenly flashed into brightness and then gradually faded away, until, in less than two seconds, nothing remained but the lines I had been watching. The slit was very close, and the definition perfect. Of course, I cannot positively assert that all the bright lines held exactly the same position that had been occupied by dark ones previously, but I feel very sure of it, as I particularly noticed several groups, and the whole arrangement and relative intensity of the lines struck me as perfectly familiar. Mr. Pye saw the same thing for an instant only. Prof. Winlock did not, as his telescope at the time, in accordance with his directions, was pointed to a spot at some distance from the sun's limb. Mr. Abbay did not see it.

This observation is a confirmation of "Secchi's continuous spectrum" at the edge of the sun, and, I think, tends to make tenable the original theory of Kirchhoff as to the constitution of the sun, and the origin of the dark lines in the ordinary solar spectrum.

I must not close this communication without a reference to the courtesy and kindness we received from the inhabitants of Jerez. Everything possible was done to assist us, and to make our stay agreeable.

Yours, very truly, C. A. YOUNG.

Jerez de la Frontera, Dec. 23, 1870.

DEAR SIR:—I wrote you from Southampton, enclosing a description of the polarising eye-piece, which I promised to supplement by a drawing, that I have been unable to find opportunity to make. Should you be able to make use of what I then sent, unillustrated, I shall be glad to have you do so.

Yesterday began with rain and clouds. Five minutes before totality the sky was overcast, and the sun quite invisible. A wonderful good fortune gave us a rift of blue sky at the critical place and time, and we did very fairly, though working partly through light haze.

Prof. Young (who, I suppose, has written you,) comes out well, having followed 1474 fifteen minutes from the sun, and three independent observers found it the brightest visible line.

Prof. Pickering and I were half a mile apart. Both of us saw what seemed evidence of radial polarization in corona, but the observation of the atmospheric polarization was difficult, and not, perhaps, conclusive, except as to the fact that this year's polariscope results show corona to be in part reflected light. How far this is due to absence of last year's cloudless sky I can't say. The corona was, to my naked eye, quite different from that I saw in Kentucky.

Mr. Willard has one good coronal picture, showing structural lines. I saw none of the striation apparent last year in telescopic scrutiny. We feel well content with our fortune, which is better than that of the English parties in our neighbord.

Very truly yours, S. P. LANGLEY.

Prof. Morton.

Civil and Mechanical Engineering.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from page 42.)

Science in its researches has left but few nooks in the industrial arts unexplored, every detail of shop manipulation, every conceivable application of mechanical forces, has, with but few exceptions, passed through the ordeal of scientific criticism and investigation.

Even the most simple matters have become the subject of abstruse mathematical calculation and are demonstrated in formulas that are a hundred fold more complicated than the operations themselves. This zeal to apply mathematics to our shop manipulation, or rather to all matters pertaining to mechanics has, no doubt, in a large measure, to be imputed to a recent realization of the fact, that they are intimately connected, are one and the same. Our shops in this country were, for the most part, founded on the "cut and try" principle; to start with, there was a popular distrust in *book* learned mechanics, and even yet in many parts of the United States there exists a strong distrust of any proposition relating to mechanics that is not based strictly upon experiment and shop demonstration. Such distrust was not without its reasons, as will be noticed further on.

But now that experience has found that the mechanics who rely upon scientific data, and who follow the laws of construction as laid down from the deductions of scientific men, are the only ones to succeed; it has not only awakened an interest but a pride in the amount of such knowledge possessed in our shops. This zeal to study theoretical mechanics is sufficiently attested in the number of polytechnic and other scientific institutions of learning of this kind that has sprung up in our country.

The discovery of the mechanical equivalent of heat has done much to restore confidence in the theoretical laws of mechanics. Without this philosophy a link in the chain was wanting; there was a stopping point to theoretical deductions about forces; much that could not be explained in a manner sufficiently rational to gain

the confidence of mechanics, when they had been educated to regard *book learning* on the subject as pernicious and almost unfitting one for the shop.

Everything in nature is the subject of fixed laws. To interpret them is the business of science, and to spread before the mechanic a chart on which he can rely. An apprentice who enters the shop with the impression that the business he is about to learn is something mysterious, and that he is to grapple about in the dark stumbling upon his ideas, solely from experiment, will never master his trade. There must be a fixed confidence in constant results; he must, to succeed, well know that all he is to learn is governed by fixed and unalterable laws which science has with the aid of experiment interpreted. That there is a tangible something which he can in time master, and that he can *learn his trade*, a proposition that would be untenable unless his business could be considered as a demonstrated art.

After this much in regard to scientific research in the mechanic arts, we intend to allude to a few things that seem to have been overlooked or forgotten.

In a previous article the counterbalancing of the reciprocating parts of machinery was alluded to with the promise that it would be taken up in connection with reciprocating saws. It was overlooked at the proper time but will not be out of place here. The subject of counterbalancing as applied to reciprocating movement is one of these *nooks* that seems to have escaped the scientific research that has been so lavishly expended on matters of much less importance,—a reason for this was no doubt set forth in the introduction to these articles when wood-working machines were placed in the same category. Aside from the reciprocating parts of the steam engine, the question of such counterbalancing is confined mainly to wood tools; not that cutting operations on other material is much the same, but it is only in wood-cutting that a high velocity is needed and a corresponding necessity for counterbalancing exists.

Counterbalances on saw mills and scroll saws is a theme as old as our country. Old millwrights who built our "log sawing" mills of rude and imperfect construction in the absence of anything but their personal judgment and experience to guide them had nothing of more interest to argue or differ about than counterbalances.

A journal claiming to be scientific has, to within a few months past published numerous communications on the subject of such counterbalances, containing a diversity of opinions which prove conclusively that there are no scientific data to determine the matter, at least in any form that is available to mechanics generally, and justifies the assumption that one important feature in construction has been overlooked in our voluminous text books.

Another thing intimately connected with counterbalancing rotary and reciprocating parts of machines, is centrifugal strain. What should be the diameter of a bolt that will safely hold a cutter weighing one pound revolving 1000 revolutions per minute in 24 in. circle, is a question that would be difficult to answer from any text book that has come to the knowledge of the writer.

Such questions are of vital importance in the construction of wood machines, where there is great danger attending their operation even when the greatest judgment is used in attaching cutters and other details that have high motion.

To a question as to where a cutter was that was thrown out of a machine in motion. The writer received the following reply from the man who was operating it, "It is enough to know that it did not go through me. I never yet saw a cutter that came out of *that* machine." Numerous and serious accidents arise from imperfect fastenings for cutters in wood machines, and argues a necessity for some more reliable standard than that of mere judgment.

A patent granted to Captain John Ericsson during his *Monitor* career for counterbalancing the reciprocating parts of machines, was about the first published matter that directed attention to the true theory of counterbalances in this country. It was comprehensive, and showed the acquaintance of this celebrated engineer with the matter. It related in substance to counterweighting the reciprocating parts of machines by means of balances of equal weight with the parts, having a coincident movement in a reverse direction; or of weights greater or less with a proportionate range of movement, inverse of course. These may not be the precise words of the patent, which is quoted from memory, but are the claims in substance.

In 1866, about the same time or about the same year of the Ericsson patent, Mr. James R. Maxwell, a mechanical engineer of Cincinnati, Ohio, designed an eccentric turning lathe on the same principle, having a compound face plate or sliding frame, so ar-

ranged that the amount of ponderable weight was at all times the same on every side of the axis, independent of the piece being turned. These lathes are used for turning oval picture frames and other like work and are among the most difficult of all machines to "hold still," so much so that in some instances it has been found necessary to build a solid wall of masonry over them, so that the vibration would fall in its plane.

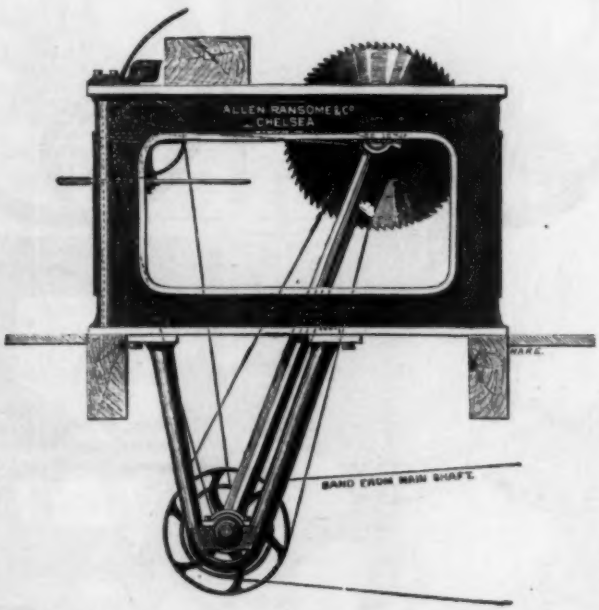
Fig. 1.

With Mr. Maxwell's improvement these machines are operated on the floor like a saw or molding machine, and cause no jar or vibration that is not absorbed by the counterweight.

It will be quite impossible to consider this question of counterbalances in connection with reciprocating motion without diagrams which may be prepared in some future number. The present purpose is to direct attention to it as a thing that has been neglected.

To resume the wood machine notices we present at Fig. 1 in this number a perspective elevation of a surfacing plane invented by B. D. Whitney and manufactured at his works in Winchendon, Massachusetts.

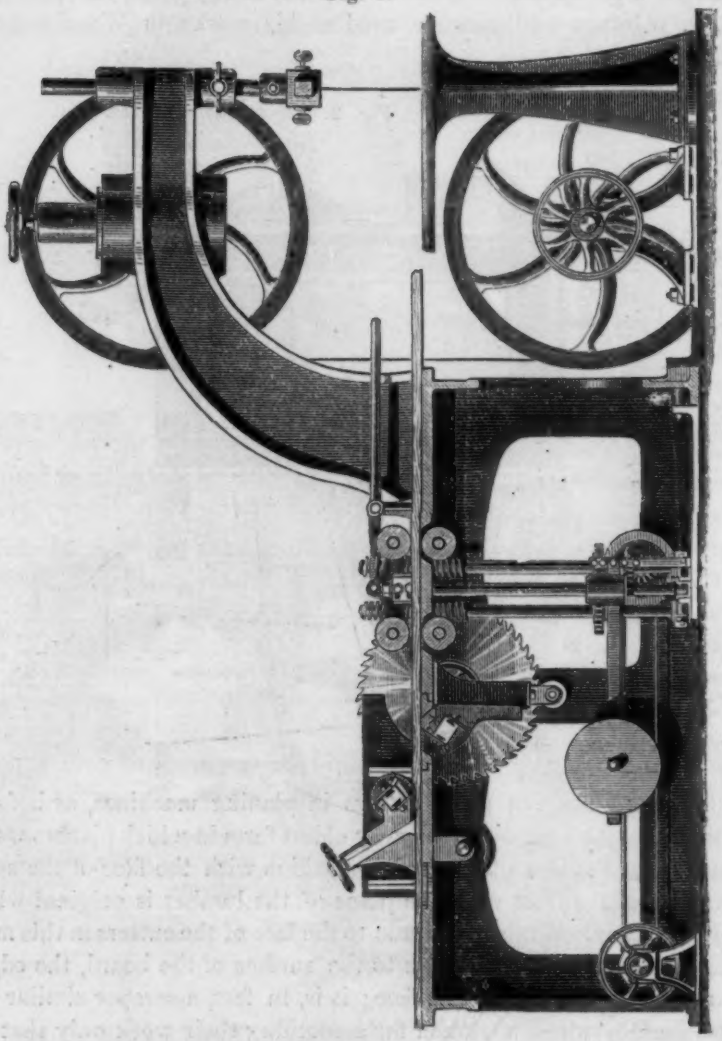
Fig. 2.



The application of fixed cutters in planing machines, as before noticed, is quite old if not the very oldest form in which planers were made; but the idea of a scraping machine with the face of the cutters at right angles with the plane of the lumber is original with Mr. Whitney. While we allude to the face of the cutters in this machine as being at right angles to the surface of the board, the edge is not a continuation of this face; it is, in fact, a scraper similar to that used by wood workmen for smoothing their work only that it is on a more extensive scale, and the operation performed by power instead of by hand. The knives or cutters are thin sheets of steel

which are "set" with a turned edge like a currier's knife before being placed in the machine. The lumber is forced through by a strong arrangement of feed rolls, and is gauged from its bottom surface which is the side acted upon by the cutters.

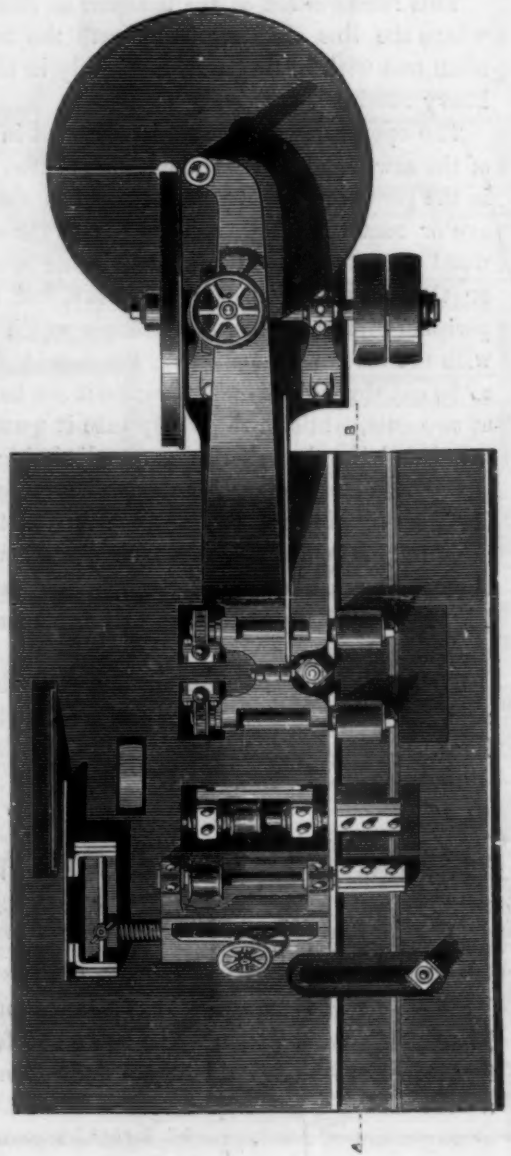
Fig. 3.



This machine, so far as there is any information at command, is a purely American invention; no application of power to scraping

wood on the principle here employed seems to have been made by manufacturers of wood machines in other countries; in fact, the machine would meet with opposition if introduced into many parts of the old world. It takes the place of a kind of hand skill that has not been reached by other machines, that of smoothing up stuff after it has been planed on the common planer, and would no doubt be regarded as taking "the bread from the mechanic's mouth," a cry that has not yet died out even in England.

Fig. 4.



Chair stuff, furniture stuff and even veneered lumber is brought to a perfectly smooth surface and from the undulations left by rotary cutters when passed through these machines. This machine was exhibited at Paris in 1867, and was awarded a silver medal in the great exposition.

Fig. 2 is a side elevation of a cross cutting saw from the de-

signs of Allen Ransome & Co., London, England. It is what would in America be termed an inverted "swing saw," the pivotal joint being beneath instead of above the machine as they are generally arranged in our shops.

This modification of the machine as shown is adapted to shops where the line shafting is beneath the mill floor, a plan that is often met with in England, but rarely in this country except when heavy machines are used.

The operation of the saw is different in the two cases, the axis of the saw being, in the machine illustrated below the lumber, while in the pendulum or overhead saw, it is above; in the one case the eye or centre of the saw is on the gauge side of the stuff, and the wood passes near to the collars; in the other, the eye of the saw is on the varying side of the lumber, and the cutting done on the periphery of the plate—differences which leave great advantages with the machine illustrated; for should the lumber be too thick to be cut through at one operation it can be turned over and severed at two cuts, while in the other case it would not pass beneath the saw mandril unless there was an adjustable table to carry it.

Fig. 3 is a side elevation from a heavy compound machine manufactured by Messrs. A. Ransome & Co., for sawing, planing and molding. The drawing is a true elevation to a scale of $\frac{1}{24}$th, and shows the arrangement of the machine, together with the plan at Fig. 4, so perfectly that no special explanation is needed to make it understood.

There are top and bottom cutters, and side cutters on the molding side, a circular saw on the opposite side with a band saw for curved lines.

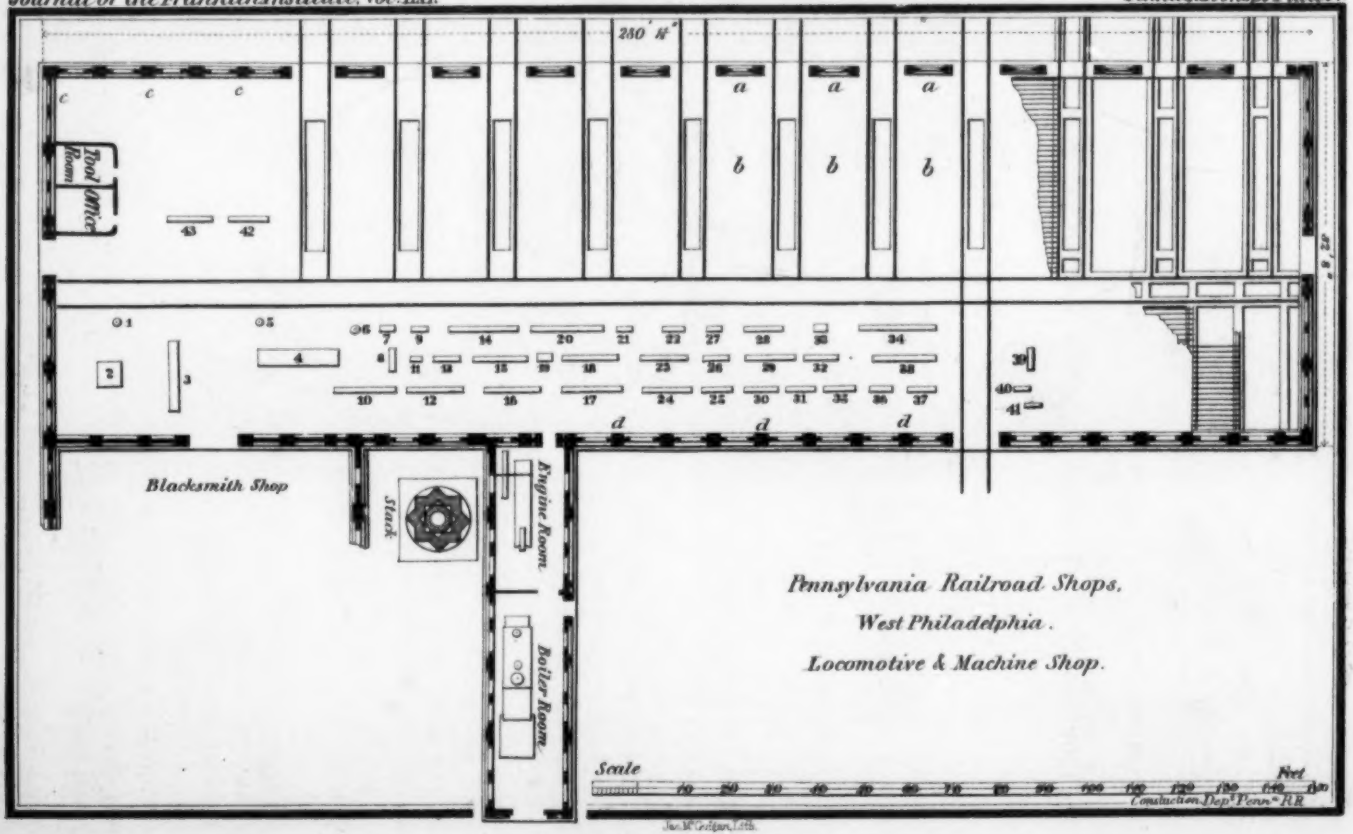
(To be continued.)

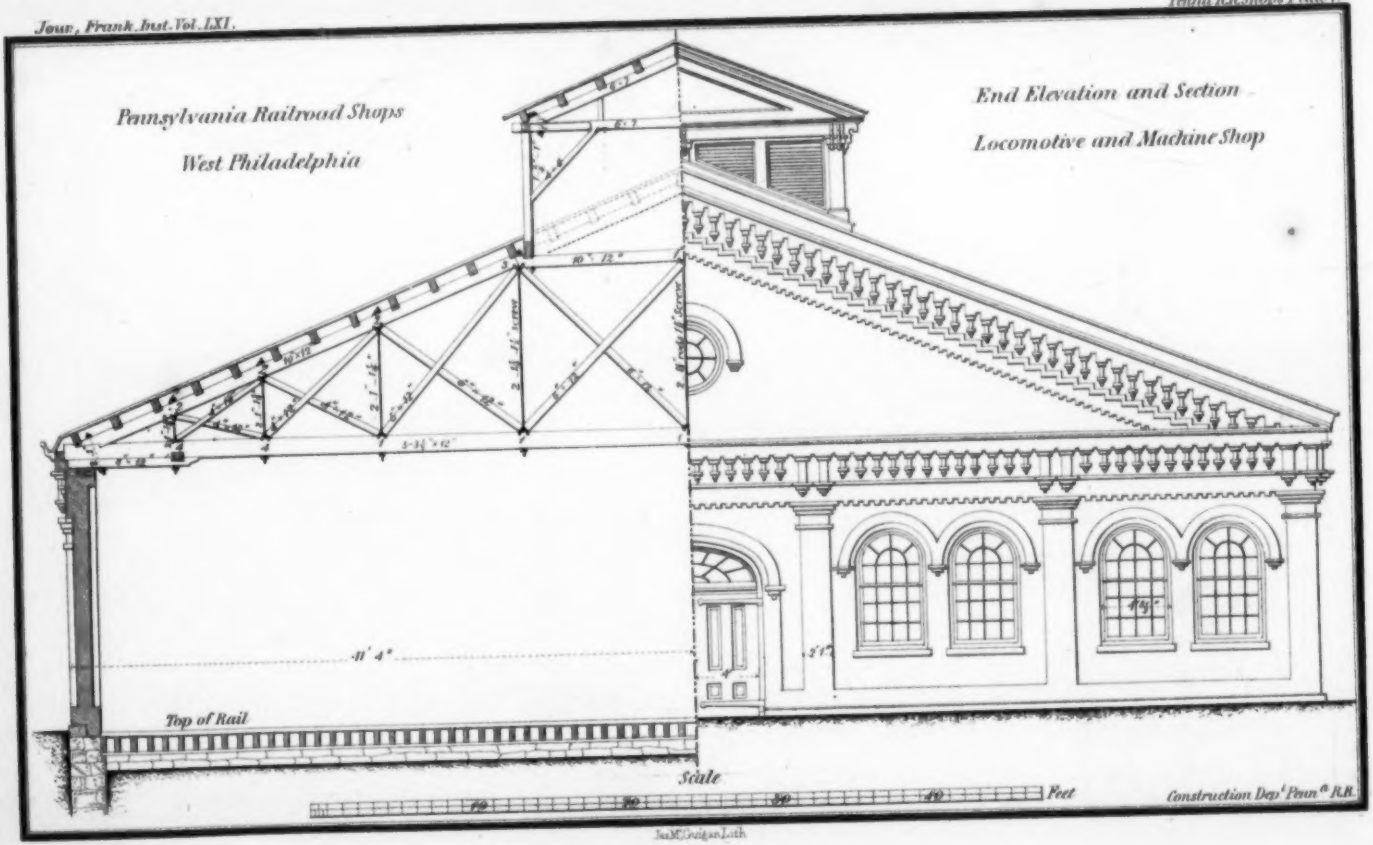
THE PENNSYLVANIA RAILROAD SHOPS AT WEST PHILADELPHIA.

By Joseph M. Wilson, C. E.
[P. A. Engineer, Construction Department, Pennsylvania Railroad.]

(Continued from p. 317, Vol. LX.)

Locomotive and Machine Shop.—This building, numbered 2 on Plate I, is a rectangle in form, being 280 feet 1½ inches long by 82 feet 8 inches wide, outside dimensions of brick wall, and furnishing a floor area of 21,840 square feet. Plate IV is a plane showing the arrangement of tracks, positions of doors, windows, machinery, &c. Plate V shows an end elevation and section. Plate VI gives de-


230 ft.
Tool Room
Office
Blacksmith Shop
Stack
Engine Room
Boiler Room
Pennsylvania Railroad Shops.
West Philadelphia.
Locomotive & Machine Shop.
Scale
Feet
Construction Dep.t Penn.a R.R.


Pennsylvania Railroad Shops
West Philadelphia
End Elevation and Section
Locomotive and Machine Shop
11' 4"
Top of Rail
Scale
Feet
Construction Dep.t Penn.a R.R.
Jas. McCreight Lith.

Pennsylvania Railroad Shops
West Philadelphia

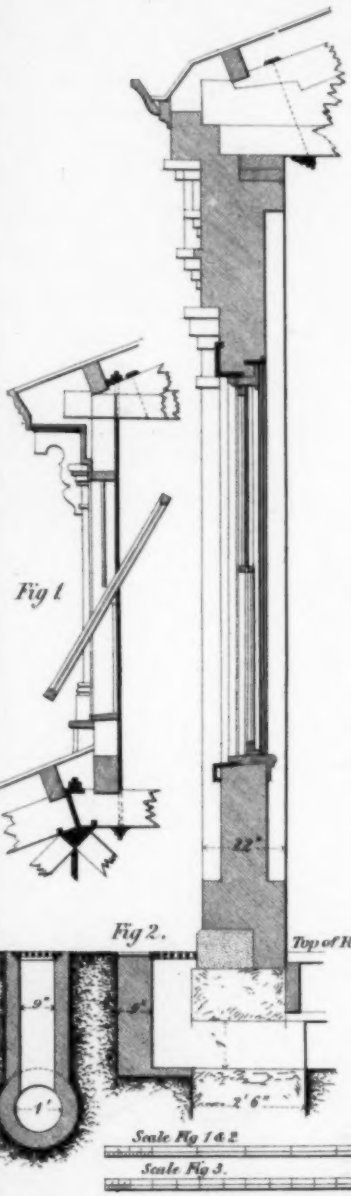
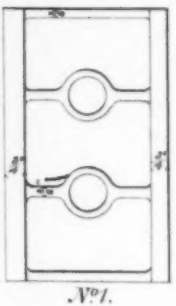


Fig 1

Fig 2.



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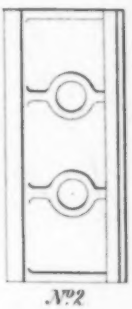

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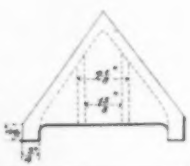
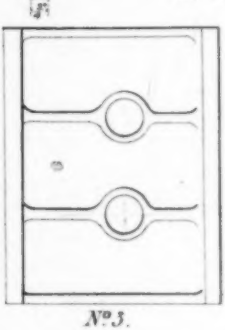


Fig 3



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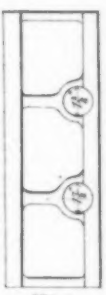

No 4.

Details
Locomotive & Machine Shop.

Scale Fig 1 & 2. Feet

Scale Fig 3. inches

Construction Dep.t Penn.a R.R.

Jas. McGilvan, Lith

tails. Plate VII is a section through engine and boiler rooms, and Plate VIII gives elevation, section and details of stack.

There are tracks for eleven locomotives, each provided with a pit. The details of construction of the walls of the building, and also of the pits, are the same as in the locomotive house. The outer foundation walls are 2 feet 6 inches thick, and all inner walls 2 feet. The outer wall finishes off 4 inches below the surface of the ground, and has a belting course on top of cut stone, 9 inches by 15 inches section. All of the doors have cut stone sills 12 inches deep, and where the tracks run through, the rails are cut into the stone, as in the locomotive house, so as to give a flush surface on top. Above the belting course the walls are of brick, built in panels, with pilasters inside and out, and ornamental cornice outside, as shown in plates. Air passages are built in the foundation walls at frequent intervals, to allow of ventilation under the flooring. These are built up to the surface of ground on outside, and are covered with a cast iron grate, flush with the ground line. Fig. 2, Plate VI, shows details of wall with this ventilating passage, and also gives a section through the sewer, showing arrangement for surface drainage. The area between the front of the building and the transfer table is paved with brick. Sewers extend all around the building, and surface drainage is provided between the tracks, and at all necessary points. The pits and the roofs also drain into the sewers. The large doors at the entrance tracks are 11 feet by 15 feet 10½ inches clear opening, and have elliptical heads, the distance from floor to springing line of arch being 12 feet, and the rise of arch to crown 3 feet 10½ inches. These doors are made in two thicknesses of 1¾ inches each, the central portion being glazed. Some of these doors have wickets and some are without. Those with wickets are glazed 2 lights high by 4 lights wide, 13-inch by 20-inch glass, and those without wickets 4 lights high by 4 lights wide, of same size glass. The upper elliptical segments and the lower portions of the doors are paneled and moulded on the outside, and sheeted diagonally on back with tongued, grooved and beaded stuff. These doors all open out, and are hung on heavy cast iron hinge blocks, built into the brick work, three wrought hinges to each door, and they are provided with the same furniture as those in the locomotive house.

In each gable end of the building is an elliptical headed door opening, 8 feet wide, 8 feet 8 inches in height from floor to springing

line, and 2 feet 6 inches rise of arch from springing line to crown. The doors are square at the top, being provided with transome and 5-inch impost, and are 2 inches thick, paneled and moulded on front, and sheeted diagonally on back with narrow 1-inch tongued, grooved and beaded boards. They are hung on cast iron hinge blocks, two wrought iron hinges to each door. The outside door to boiler room is in one piece, and raises vertically, being hung by chains and weights on pullies.

The windows in gable ends of the building are semi-circular headed. Those in the sides are square headed. All have box frames, and cast iron outside sills, and the square headed windows have cast iron outside lintels and inside lintel plates. The sash are in two flights, of 12 lights each, 12-inch by 15-inch glass, and are double hung with cord, weights and axle pullies. In each gable end is a circular window, 4 feet 6 inches, opening in brickwork, with one sash, made to swing in centre of height. The floor joist are 3-inch by 12-inch, white pine, laid 1 foot apart, centre to centre. The wall plates and track stringers are of white oak. The flooring is double, and the details in regard to this, the arrangement of track stringers, and the finish around pits are all the same as previously described in the case of the locomotive house.

The wall plates on top of brick wall are of white oak, in two thicknesses of 3 by 12 inches each, laid to break joint and well pinned together. Plate V shows the construction of the roof truss. The principals are placed 10 feet 6 inches from centre to centre. The principal rafter is of one piece, 10 by 12 inches section, and the tie beam of three pieces, $3\frac{1}{2}$ by 12 inches each, securely framed together with keys, clamps and combination bolts. The number and sizes of the vertical rods are given on the Plate, and the notation reads thus, for instance: 2 rods $1\frac{1}{4}$ inch diameter each, with $1\frac{1}{2}$ inch screw at each end. The ends of the rod are upset, so that the effective section of screw shall be the same as that of the rod. The sizes of the braces are also given on the Plate. Where the braces cross, one is cut, the parts being kept in proper position by dowel pins. The angle blocks are of cast iron, of the forms and dimensions shown, Fig. 3, Plate VI. The blocks are numbered, and the numbers, as marked on the elevation of roof, show their several positions in the truss. Tubes are provided for the rods where they pass through the timber, to prevent the compression of the wood. The purlins are $4\frac{1}{2}$ by 8 inches section, placed 3 feet apart and securely spiked to the principals, at intervals, by $\frac{5}{8}$-inch wrought

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spikes. The ventilator, the details of which are shown on Plate V, and Fig. 1, Plate VI, runs to within one panel of each gable end of the building. The sides of the ventilator have glazed sash, hung to swing on centre, as shown. By a simple arrangement the sash are so connected together in sets, that by means of a rope they may be readily opened and shut from the floor below, quite a number of sash at one time. The roof sheeting is of white pine 1-inch boards, brought to a surface and worked. The slate is of the best quality, from the Lehigh quarries of Pennsylvania, and of size 10 by 20 inches, laid to weather 8½ inches.

The gutters, valleys and eave pipes are of copper, gauge No. 24. The eave pipes run down into the sewers, and are protected by a cast iron guard near the ground. The building is warmed by cast iron stoves, chimneys being built into the side walls at intervals.

The following is a list of the machinery in the building, numbered to correspond with the plan, Plate IV:

No. 1. Crane. Capacity, 2 tons.
" 2. Wheel Boring Machine. Wm. Sellers & Co., makers.
" 3. Hydraulic Wheel Press. " " " "
" 4. Wheel Lathe. " " " "
" 5. Crane. Capacity, 5 tons.
" 6. Drill Press. Centre of spindle to post, 12 inches; vertical movement of table, 18 inches; hand feeding. Bement & Dougherty, makers.
" 7. Drill Press. Centre of spindle to post, 18 inches; vertical movement of table, 34 inches; hand feeding. Wm. Sellers & Co., makers.
" 8. Grindstone.
" 9. Slotting Machine. From tool to upright, 22 inches; length of stroke, 15 inches; feed motion; circular and horizontal. William Sellers & Co., makers.
" 10. Slide Lathe. Length of shears, 10 feet 3 inches; swing, 20 inches; back geared; screw cutting. Bement & Dougherty, makers.
" 11. Nut Facing Machine. Bement & Dougherty, makers.
" 12. Shaping Machine. Length of shears, 13 feet 1 inch; length of stroke, 12½ inches; double head; feed motion; horizontal, vertical and circular. Wm. Sellers & Co., makers.
" 13. Set Screw Machine. Bement & Dougherty, makers.
" 14. Slide Lathe. Length of shears, 14 feet 10 inches; swing, 30 inches; back geared; screw cutting. Wm. Sellers & Co., makers.
" 15. Slide Lathe. Length of shears, 12 feet 6 inches; swing, 25½ inches; back geared; screw cutting. Wm. Sellers & Co., makers.
" 16. Slide Lathe. Length of shears, 14 feet 3 inches; swing, 25½ inches; back geared; screw cutting. Wm. Sellers & Co, makers.
" 17. Slide Lathe. Length of shears, 12 feet 6 inches; swing, 20½ inches; back geared; screw cutting. Wm. Sellers & Co., makers.
" 18. Slide Lathe. Length of shears, 12 feet 6 inches; swing, 20½ inches; back geared; screw cutting. Wm. Sellers & Co., makers.

No. 19. Shaping Machine. Length of shears, 44 inches; length of stroke, 9 inches; single head; feed motion; horizontal, vertical and circular. Wm. Sellers & Co., makers.

" 20. Slide Lathe. Length of shears, 16 feet 10 inches; swing, 44 inches; back geared. Bancroft & Sellers, makers

" 21. Cotter Drill. Centre of spindle to frame, 15 inches; movement of head, 3) inches; vertical movement of table, 18 inches; self-feeding. Wm. Sellers & Co., makers.

" 22. Drill Press. Centre of spindle to post, 20 inches; vertical movement of table, 18 inches; self-feeding and geared. Bement & Dougherty, makers.

" 23. Slide Lathe. Length of shears, 13 feet; swing, 20 inches; back geared; screw cutting. Bement & Dougherty, makers.

" 24. Slide Lathe. Length of shears, 10 feet; swing, 20½ inches; back geared; screw cutting. Wm. Sellers & Co., makers.

" 25. Slide Lathe. Length of shears, 8 feet; swing, 16½ inches; back geared; screw cutting. Wm. Sellers & Co., makers.

" 26. Slide Lathe. Length of shears, 8 feet; swing, 16½ inches; back geared; screw cutting. Wm. Sellers & Co., makers.

" 27. Slotting Machine. From tool to upright, 14 inches; length of stroke, 10 inches; feed motion; circular and horizontal. Wm. Sellers & Co. makers.

" 28. Horizontal Drill and Boring Mill combined. Table, 48 inches by 23 inches, with 18-inch vertical movement; movement of spindle, 24 inches; double rest, self-feeding. Wm. Sellers & Co., makers.

" 29. Hand Lathe. Length of shears, 12 feet 4 inches; swing, 16½ inches. Wm. Sellers & Co., makers.

" 30. Slide Lathe. Length of shears, 7 feet 10 inches; swing, 12½ inches; back geared; screw cutting. Wm. Sellers & Co., makers.

" 31. Slide Lathe. Length of shears, 7 feet 10 inches; swing, 12½ inches; back geared; screw cutting. Wm. Sellers & Co., makers.

" 32. Planing Machine. Length of shears, 4 feet 7 inches; length of carriage, 3 feet 10 inches; width of post, 19 inches; height of post, 18 inches. Wm. Sellers & Co., makers.

" 33. Drill Press. Centre of spindle to post, 18 inches; vertical movement of table, 34 inches; hand feeding; Wm. Sellers & Co., makers.

" 34. Planing Machine. Length of shears, 22 feet 4 inches; length of carriage, 14 feet 7 inches; width of post, 36 inches; height of post, 36 inches. Wm. Sellers & Co., makers.

" 35. Hand Lathe. Length of shears, 5 feet; swing, 14 inches. Fox Patent.

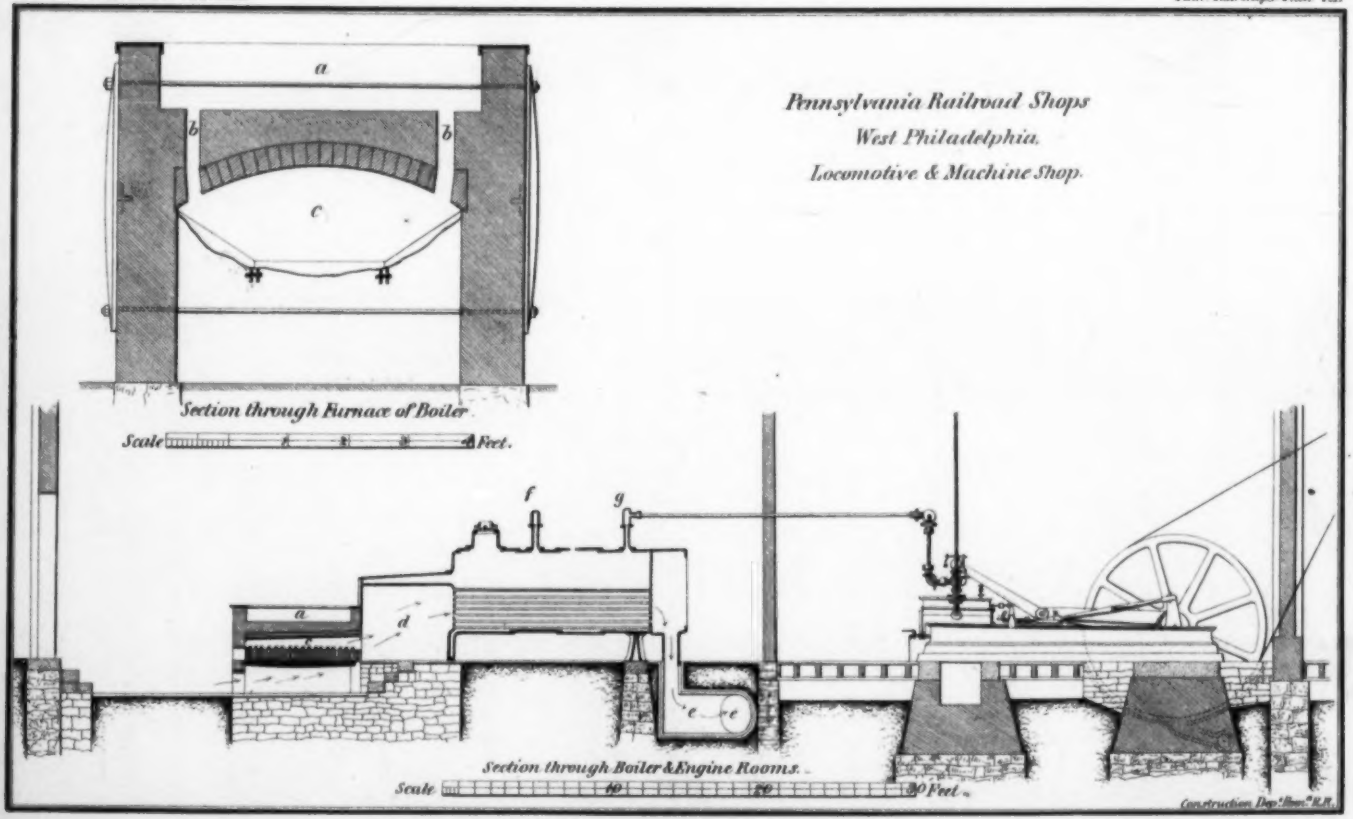
" 36. Planing Machine. Length of shears, 6 feet 6 inches; length of carriage, 5 feet 4 inches; width of post, 19 inches; height of post, 18 inches; Wm. Sellers & Co., makers.

" 37. Planing Machine. Dimensions same as No. 36. Wm. Sellers & Co., makers.

" 38. Planing Machine. Length of shears, 15 feet 8 inches; length of carriage, 10 feet 6 inches; width of post, 25 inches; height of post, 24 inches. Wm. Sellers & Co., makers.

" 39. Drill Press. Centre of spindle to post, 22½ inches; vertical movement of table, 24 inches; self-feeding and geared. Wm. Sellers & Co., makers.

" 40. Grindstone.

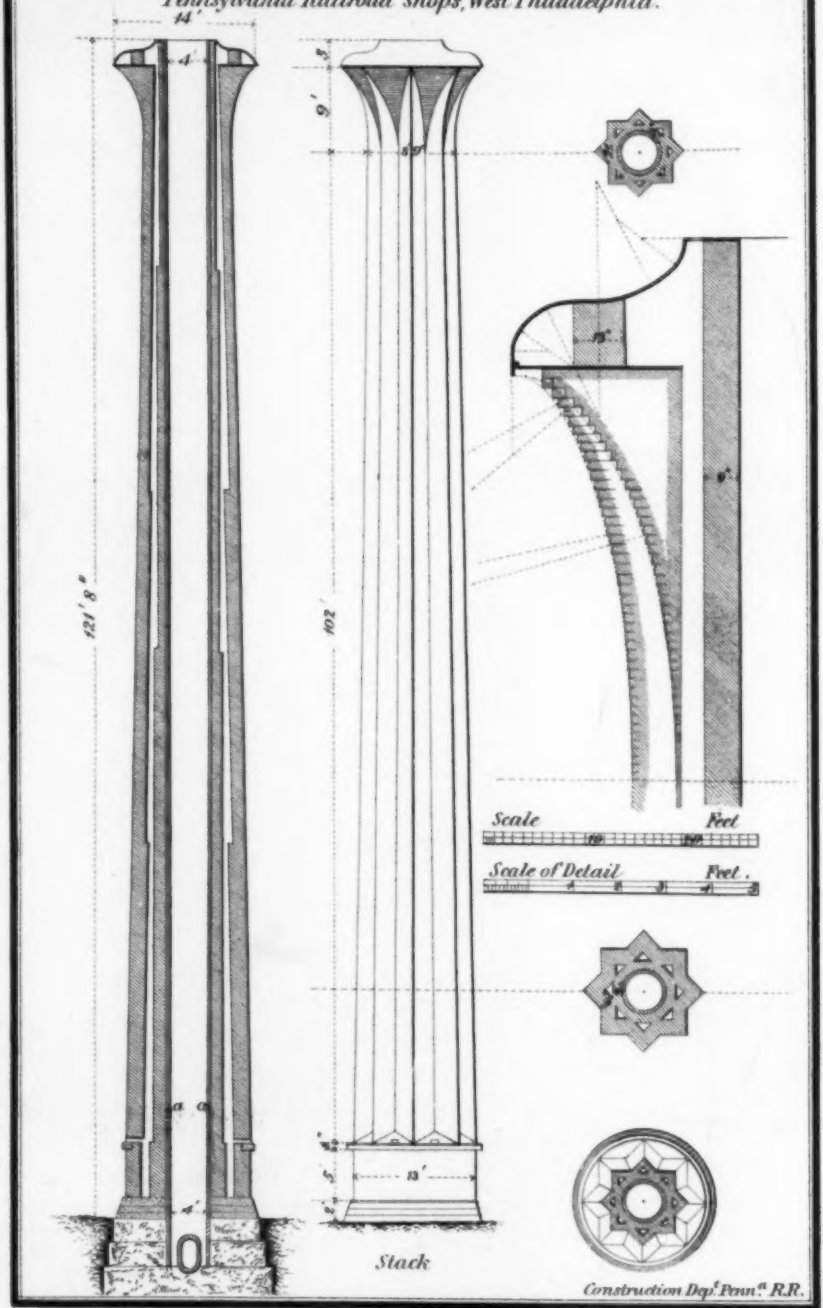


Pennsylvania Railroad Shops
West Philadelphia.
Locomotive & Machine Shop.

Construction Dep.t Penn.a R.R.

Lith. Jas. McGregan, Phil.a

Pennsylvania Railroad Shops, West Philadelphia.



Jas.M. Guigan, Lith.

No. 41. Two Screw Cutting Machines. Wm. Sellers & Co., makers.
" 42. Slide Lathe. Length of shears, 9 feet; swing, 16 inches; back geared; screw cutting. Bement & Dougherty, makers.
" 43. Slide Lathe. Length of shears, 10 feet; swing, 20½ inches; back geared; screw cutting. Bement & Dougherty, makers.
" 44 Drill Press. Overhead For drilling tires; hand feeding. Bement & Dougherty, makers.
" 45. Milling Machine. Length of carriage, 42 inches; raise of cutter, 4 inches; index plate and centres attached. Wm Sellers & Co., makers.

Nos. 44 and 45 have been accidentally omitted on the Plate. No. 44 is located between No. 42 and the track running lengthwise in the building. No. 45 is between No. 1 and the gable end wall.

It is intended occupying the space beyond No. 41 with some new machinery not yet purchased.

Between the tracks, as at *b*, *b*, &c., and along the walls at *a*, *a*, *d*, *d*, *c*, *c*, &c., are located work benches. Each bench has a drawer and closet attached, both being furnished with lock and key, numbered to correspond with a number on the closet. Each workman, therefore, has his own bench, with a closet in which to keep his hat, coat, over-hauls, &c., and a drawer for his tools, all under his own control.

Plate VII shows a section through the engine and boilor rooms. The engine was rebuilt from an old one constructed by Samuel V. Merrick & Sons, some years ago, and in use by the Company before the building of this shop. It is about 90 horse power, diameter of cylinder 16 inches, length of stroke 40 inches, and is provided with a Huntoon governor, but otherwise does not merit attention. The diameter of band wheel is 12 feet.

The boiler was built at Altoona, Penn., R. R. shops. It is of ⅜-inch boiler plate, of the form known as locomotive boiler. What was originally the fire box is now used as a combustion chamber, a self-feeding furnace of brick, lined with fire brick, being built in front as shown on Plate. The fuel used is fine refuse of anthracite coal, and is piled up over the furnace in the part, *a*, from which it feeds down through a series of small square section openings, *b*, *b*, arranged 4½ inches apart, the whole length of the furnace. The fireman, in poking the fire, by running his poker along under the openings, back and forth, can easily regulate the admission of fuel as needed. The boiler is provided with a pair of Richardson's safety valves, a gauge of the Cleveland Gauge Company, registering to 200 pounds, and is fed by an injector.

At *f* a steam pipe goes off to blacksmith shop, to supply steam to hammers. At *g* a steam pipe connects with the engine. The

smoke box of boiler connects, by a passage, *e*, *e*, with the stack. (See Plate VIII.) In this passage, where it runs under the wall of the building, is a slide valve, raised and lowered by means of a winch and chain, to regulate the draft. It usually requires to be kept open about 10 inches. The arrangement of furnace appears to work very satisfactorily.

The stack is of brick, with a cut stone base and cast iron cap, and has a total height of 121 feet 8 inches, the inner diameter of flue being 4 feet. The section is an eight-pointed star, the points of the star being built hollow, with openings to the outer air at bottom and top. There is an inner lining of one brick thick, 4½ inches, not bonded in with the rest of the work, which, as far up as *a*, *a*, is of fire brick, but above that, of ordinary hard brick. The cap is cast in sections and bolted together.

[NOTE.—There are several important improvements we could suggest in this building, especially in the construction of the roof truss, which is faulty in several respects, but as we propose at the conclusion of these articles giving a general review, and taking up questions of this kind, we will not, therefore, consider them here.]

(To be continued.)

THE FAIRLIE ENGINE.

[We have received from the author a copy of a letter on the Fairlie Engine, the accompanying abstract of which we are sure will greatly interest most of our readers.—EDS.]

To the Editor of Engineering:

For the past four years I have noticed in the columns of your valuable paper, and in other papers, long articles on what is called the "Fairlie Engine." I have received pamphlets and accounts of trials of the "Fairlie Engine," and I have seen evidence enough to prove, as far as mere statements can prove a thing, that this so-called Fairlie Engine is a big wonder, and that its merits, if it has any, are being pushed by a man of energy and activity, who has by this time probably brought it to as near perfection as it is capable of being brought. Having for years been deeply interested in Mountain Railways, where steep gradients and numerous sharp curves became a necessity in climbing to summits of great elevation, I naturally studied all the mechanical contrivances and inventions applied to locomotives to overcome these difficulties. It became a necessity, long years ago, in the railway practice of the United States, to have locomotives and cars also that would traverse sharp curves, and steep gradients on mountain sides, during

the storms and frosts of winter, when all irregularities of track were held as in a giant's vice and irreparable; also during the spring, when this giant's grip was loosened, and mud took the place of adamantine hardness; and to do this with speed and safety, that was the problem to be solved, and it was solved by the adoption of a swiveling truck under the forward part of the locomotive, which was called a Bogie, after a two-wheeled vehicle of that name used in the streets of Newcastle, in England. This was done at the recommendation of George Stephenson, he having proposed it to Robert L. Stephens, of the U. S., in 1832. After listening to the difficulties we must face in adopting railways in this country, I received this information as to the origin of the name, and the first introduction of the Bogie in railway practice, from Mr. Robert Stephenson, in London, 1853. I cannot here refrain from expressing my belief that had George Stephenson lived a few years longer, with the influence, and wonderful mechanical instinct, that rare gift which he possessed in such abundance, the great merits of the Bogie system would have been acknowledged and adopted throughout the whole United Kingdom, as well as in the United States. And it may possibly have been the case that one or more of your readers would have opened their eyes to the fact that England owed a Dukedom to George Stephenson more than she ever owed it to any other mortal. The Bogie was adopted in this country; it had an English origin, but here is its home; here it has been petted, and nursed, and twisted, and turned, and made to do all manner of things, in running around corners of streets and making itself feel at home everywhere, on 50,000 miles of track, good track (if you will allow we have such a thing) and bad track, rough track and smooth track, up hill and down hill, over the mud of spring and the frost of winter, through rain storms and snow storms, over mountains and under mountains, from ocean to ocean, in almost endless forests, over trackless bogs and rolling prairies, where ballast is unknown and unattainable. In the dreary North and the sunny South, there is not a minute in the day or night "when the voice of the Bogie is not heard in the land" (*I mean the meritorious, pecuniary, dividend-making, rail-saving "voice"*), as it carries above it the eagle eye of the engine driver and the life of the sleeping passenger, as thousands on thousands of them are whirled through space in safety, as far as the Bogie is responsible. We claim the Bogie as ours; we love it, place our faith in it, and defy any other people to make it do more for them than it has done for us. When Mr. Fairlie took up the long exploded idea of a double Bogie Engine to work sharp curves and climb mountain gradients, he jumped out of a groove, in which he had seen only the stereotyped model engines which your paper in October, 1868, very wittily termed a six-footed beast. He did not know that such engines on our roads would ruin us in a year; he did not know what wonders we had made the Bogie perform in its dress of late

years, of radial bars, swing-links, and equalizing levers fore and aft, and cross-ways; and what is more, he did not, would not, and could not see it when he came here. Although it was shown to him, by the most extensive engine builder in this country, he insisted that what he saw was not so. If Mr. Fairlie had seen things as they were, and not as he wished them to be; if he had possessed a portion of the mechanical instinct that made George Stephenson's name a pride throughout the engineering world, he would have returned to England (as an English engineer said to me a short time since) a wiser man, for he could have seen on many railways in the U. S. that American Engineers have done with the single Bogie, and its various mechanical appliances, more than he has ever done, or ever can do, with his double Bogie engine; he could have saved himself much trouble, waste of precious time, and anxiety of mind, over an invention which is condemned by the leading locomotive engineers of the world, and particularly the engineers of England, and he would probably have saved some railway companies considerable sums of money. Having said so much, and intending to say more, in the way of criticism, and in the face of the opinion of the great *London Times*, and the certificates of Dukes and Counts, that this so-called Fairlie Engine is a wonder, I will add that when Mr. Fairlie can show me on mountain grades and sharp curves as much work done in proportion to weight on drivers, and at the same cost, as I can show done by American Engines, I will become a convert, adopt his system, and give him the entire benefit of it, if he can prove to me that any part of it had its origin in his brain.

Wishing to know the comparative merits of the so-called Fairlie and the American Bogie Engine, I have, thinking that figures put down in all honesty would not lie, taken trials of two of the Fairlie Engines as printed by himself, and vouched for by a Duke, a Count, and other railway experts, and put them by the side of trials of engines built under my direction, and experimented with one in Chile by order of that Government, and one in Peru by order of that Government, both trials being witnessed by English engineers. I send you a copy of this table of comparisons; it speaks for itself. I have brought the whole four trials down, as near as it can be done, to one standard, which you will find at the bottom. It is "foot-pounds" of work done in lifting train alone, exclusive of engine, per hour, per ton of weight on drivers, calculated from weight of train, speed per hour, and elevation overcome.

Memoranda in reference to Engine Comparisons.

1st. In calculating atmospheric resistance I have used the frontage formulæ, not having the cubic feet of bulk in the train, the only proper data from which to calculate the atmospheric resisttance; the total amounts, in the cases stated, are not important, as the speed was not great.

2d. The American engines were running on tracks built by Americans, and in the American cheap style; while the Fairlie engines were running on English railway tracks, which are, in England at least, considered to be the best in the world.

3d. The "San Bernardo" was running on a track which was essentially straight, the minimum curvature being 6,562 ft. radius. The "Conquistador" was run on a track full of curves of 350 ft radius, combined with gradients of 3 per cent. (151 ft. per mile), and encountering long gradients of 4 per cent. (211 ft per mile), combined with curves of greater radius. The data for comparison was taken while running on the 4 per cent. gradients, with poor fuel and bad water. This, in a measure, accounts for the wide difference between the performance of the two American engines, for D. K. Clark, in his work on Locomotives, says, page 267: "It was estimated that a curvey line, having one curve under one mile radius for every two and a half miles, incurred an excess of resistance equal to 20 per cent. of that due to a line practically straight."

4th. In the table, the Fairlie engine, "Progress," is taken at 54 tons. Colburn told me he weighed this engine, and found it to weigh over 60 tons.

5th. The only fair and perfectly reliable way to test engine performances, is to get them on the same track, under the same conditions. But in the above table of comparisons the differences are so enormous that it is easy to tell where the greatest merit lies.

6th. Engine frictions vary greatly, but for the above calculations 10 lbs. per ton is taken as a fair average for all. Fairlie calls the frictions of his engines 18 lbs. per ton.

7th. There is no allowance made in the table for adhesion, being less on the steep gradients than on ordinary easy gradients.

8th. The American engines in both trials showed their ability to make all the steam required on the maximim gradients, in fact the fire door of the "San Bernardo" had to be kept open most of the time to keep her steam down to 115 pounds, the limit agreed on; the Fairlie engines failed to make the steam required.

9th. The Fairlie engine, "Progress," could not start her train of 472 tons on a gradient of 1 in 90 with 150 pounds of steam; the "San Bernardo," with less than one-third of the weight on drivers, started a train of 559 gross tons, and one brake screwed down, on a grade of 1 in 400, with 118 pounds of steam.

10th. Fairlie's data for calculations is not complete. The most favorable in his pamphlet for the "Progress" is that she was running with 476 tons at 8 miles per hour, with 140 pounds of steam, up a gradient of 1 in 90.

W. W. EVANS.

New York, Sept. 11, 1870.

TABLE OF COMPARISONS OF FAIRLIE AND AMERICAN ENGINES.

No.		FAIRLIE ENGINES.		AMERICAN ENGINES.	
		Little Wonder.	Progress.	San Bernardo.	Conquistador.
1	Name of Railway	Festiniog, Wales.	Mid. Wales.	Southern, of Chili.	Arequipa, of Peru.
2	Gauge of Railway	1′ 11½″	4′ 8½″	5′ 6″	4′ 8½″
3	Weight of Engine, loaded, in gross tons	19·50	54·	28·11	31·21
4	" " " " " on drivers	19·50	51·	17·48	25·89
5	" " " on each driving wheel, in gross tons	2·44	6·75	4·37	4·31
6	Number of Driving Wheels	8·	8·	4·	6·
7	Number of Wheels under each Engine	8	8	8	10
8	Length of Wheel Base	19′	21′	22′	22′ 7½″
9	Diameter of Driving Wheels, in inches	28″	54″	56½″	49″
10	Number of Cylinders	4	4	2	2
11	Dimensions of Cylinders, in inches	$8\frac{3}{16}$″ × 13″	15″ × 22″	16″ × 24″	19″ × 24″
12	Average Pressure of Steam in Boilers during trials, in pounds	175·	140·	115·	130·
13	Adhesion at 20 per cent. of weight on driving wheels, in pounds	8 733	24 192	7,831	11,599
14	Adhesion at 30 per cent. of weight on driving wheels, in pounds	13,104	36,288	11,746	17,393
15	Load hauled, excluding engine, in gross tons	121,875	476·	340 89	138·88
16	Load hauled, including engine, in gross tons	141,375	530·	369·	173·09
17	Gradient overcome—ratio of height to base	1 in 92	1 in 90	1 in 94·3	1 in 25
18	Gradient overcome, in feet, per mile	57·30	58·70	56·	211·20
19	Speed of Trains, in miles, per hour	11·25	8·	17·	10·
20	Resistances of Gravity, in pounds	3442·	13191·	6765·	15509·
21	Resistance of Rolling Friction at 5 lbs. per ton	707·	2800	1845·	865·
22	Resistance of Oscillation and Concussion $\frac{W\ V}{10}$	153·	424·	627·	173·
23	Resistance of Air (by frontage formula), say, area of 100 square feet	31·	16·	72·	25·
24	Resistance of Friction in Engine at 10 lbs. per ton	195·	540·	281·	342·
25	Total Resistances, in lbs.	4584·	16821·	11590·	16913.
26	Percentage of Weight on Driving Wheels, utilized	101¼·	14·	29½	29·
27	Pounds Traction per Ton of Engine alone	233·	311·	412·	491·
28	Proportional Power per ton, Little Wonder as unity	1·	1·34	1 77	2·12
29	Total foot pounds of work done per hour, calculated from resistances	269 319,600	710,519,040	1,040,318,400	893,003,400
30	Total foot pounds of work done per hour per ton of weight on drivers calculated from resistances	13.811,261	13,157,700	59,514,782	34,492,329
31	Total foot pounds of work done per hour (calculated from weight of Train and elevation overcome	204 179,614	557,109,120	786,855,120	818,867,840
32	Foot pounds of work done per hour per ton of weight on drivers (from weight of train and elevation overcome)	10,468,699	10,321,242	45,016,311	31,624 868
33	Foot pounds of work done per hour in lifting train, exclusive of engine (from weight of train and elevation overcome)	175,982,419	500,706,304	726,941,107	657,024,614
34	Foot pounds of work done per hour per ton of weight on drivers, in lifting train alone, exclusive of engine (calculated from weight of train, speed per hour, and elevation overcome per mile)	9,034,729	9 272,339	41,587,027	25,377,544

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 22.)

Page's Patent Tanned Leather Belting.—This excellent belting leather is made by Page Brothers, in Franklin, N. H. It possesses greater pliability, strength and durability than the ordinary tannage, will endure moisture better, is lighter, adheres to glue and cement as well as any belting, and, being softer, will answer better for round belts. It has been thoroughly and successfully tried, and costs no more than well made oak-tanned belting.

A trial showed twenty-five per cent. more adhesive power than hard oak or hemlock tanned leathers, and a test of strength proved that, while 1050 pounds broke an 1¼-inch wide oak-tanned belt, it required 1850 pounds to break the same size Page belt.

The single belts are ¼-inch, the light double belts $\frac{5}{16}$-inch, and the heavy double ⅜-inch thick.

The light double belts, which are about the same price as best single, work well on cone and flange pulleys, and, of course, very well where running free and where much shifted.

The adhesive power of this belting is so great that the single belts will not do well on cone or flanged pulleys, but run up the flange and turn over.

Mr. A. K. Rider, of De Lamatre Iron Works, N. Y., has favored me with the following:—"Our rule, which appears to work well and gives very satisfactory results, is based on the assumption that a belt one inch wide, when properly surfaced and sufficiently tight, and bearing on not less than one-third the circumference of smaller pulley, will transmit a force of 19¼ pounds *at any velocity*. The power of a belt, in foot pounds, is thus readily obtained by multiplying its velocity in feet per minute by its width in inches, and again by 19¼. The generally received rule is, 144 square feet of surface passing per minute equals one H. P., and the cohesive strength of good belting is taken at 4000 pounds per square inch of section as its breaking strength."

Friction of Belts.—"The friction of belts upon pulleys depends upon the extent to which they are tightened, the extent of circumference with which they are in contact, and their breadth. It is commonly believed that the greater the diameter of pulley, the more surely does the belt cause it to revolve without slipping.

Theoretically, however, and we believe practically, it will be found that, with equal degrees of tightness, equal breadth of belt, and equal circumstances as to perfection of contact, the friction of a belt on the circumference of a pulley is the same, whatever be its diameter. The only circumstance that can affect the constancy of the result, is that belts not being perfectly flexible, lie more closely to surfaces curved to a large radius than to those of smaller radius. When a certain amount of power has to be communicated through a belt, the speed at which the belt moves has to be taken into account, because power being pressure multiplied by velocity, the greater the velocity with which the power is transmitted, the less the pressure that has to be communicated at that speed, In this sense, then, it appears that the larger the pulley the less is the slip of the belt, because the greater the circumference of the pulley, revolving at a given angular velocity, the greater is its absolute velocity through space, and therefore the less the pressure required to communicate a given power.

"It is found, practically, that a leather belt 8 inches wide, embracing half the circumference of a smoothly-turned iron pulley, and traveling at the rate of 100 feet per minute, can communicate one horse-power.

"When less than half the circumference of the pulley is embraced, the strap must be proportionally wider; and when more than half the circumference is embraced, its width may be less.

"The law according to which the friction of a belt increases with an increased arc of contact, is of a peculiar character; but may be readily understood by comparing the friction on arcs of different lengths. If a pulley (of any diameter whatever) were prevented from revolving, and a belt passing over part of its circumference were stretched by a certain weight at each end, additions might be made to the weight at one end until the belt began to slip over the pulley. The ratio which the weight so increased might bear to the weight at the other end, would measure the amount of friction.

"For example, in experiments made to test a theoretical investigation on this subject, a belt passing over a pulley in contact with 60° of its circumference, was stretched by a weight of 10 pounds at each end. One of the weights was increased until it amounted to 16 pounds, when the belt began to slip. The ratio of 16 to 10, or $\frac{16}{10} = 1{\cdot}6$ was then the measure of the friction. When 20 pounds at each end were used to stretch the belt, the one weight was increased to 32 pounds, giving the ratio of $\frac{32}{20} = 1{\cdot}6$, the same as be-

fore; and likewise, when 5 pounds were used for stretching, the weight at one end was increased to 8 pounds, giving still the same ratio, $\frac{8}{5} = 1{\cdot}6$. So far, then, the friction was precisely proportional to the stretching weight, as might have been expected from the ordinarily received doctrine on the subject of friction. On extending the arc of contact to 120°, the ratio was found to be 2·56, or $1{\cdot}6^2$ And again, on embracing 180° the ratio was found to be 4·1, or very nearly $1{\cdot}6^3$

"The theoretical investigation brought out this result independently, and the following law may therefore be taken as established:

"If, for any given arc of contact, the one weight bears to the other, at the point of slipping, a certain ratio—for double the arc, the ratio will be squared; for triple the arc, it will be cubed; for four times the arc it will be raised to the fourth power; and so on.

"In all cases, however, much depends on the tightness of the belt, the limits to the force with which it is strained being, first, the tensile strength of the belt itself, and, secondly, the amount of pressure that it may be convenient to throw upon the shaft and its bearings. New belts become extended by use, and it is therefore frequently necessary to shorten them. Before use, they should be strained for some time by weights suspended from them, so as to leave less room for extension while in use. Wherever belts are employed, they should be of the greatest breadth, and travel at the greatest speed consistent with convenience, as it is most important to have the requisite strength in the form best suited to flexure, and the least possible strain on the shafts and bearings.

"When ropes or chains are employed, as in cranes, capstans, windlasses, or the like, for raising heavy weights or resisting great strains, the requisite amount of friction is obtained by coiling them more than once round the barrel of the apparatus. It is found that one complete coil of a rope produces a friction equivalent to nine times the tension on the rope, the barrel being fixed. Two complete coils of the rope produces a friction equivalent to 9×9 times the tension, and so on. The diameter of the barrel does not affect the result.

"Having regard to these facts, we may readily understand the force with which a knot on a cord or rope resists the slip of the coils of which it consists, for the several parts of the cord act as small barrels, round which the other parts are coiled; and the yielding nature of the material of which the barrels are composed, permits the coils to become impressed into their substance on the application of force, and prevents them from slipping more effectually than if they were coiled on a hard and resisting barrel."—*From Wylde's Circle of the Sciences. London.*

(To be continued.)

Mechanics, Physics, and Chemistry.

ON AMMONIUM AND THE SOLUBILITY OF METALS WITHOUT CHEMICAL ACTION.

By Chas. A. Seely.

In April and May last it came in my way to make a pretty careful study of the constitution of the so-called ammonium amalgam, and on May 9th, I reported to the Lyceum of Natural History of New York what I had done in the matter up to that time. Subsequently, I continued the study, and was led to the discovery of the solubility of the alkali metals in anhydrous ammonia, an account of which formed a paper read at the Troy meeting of the American Association for the Advancement of Science. Neither of these communications have been printed; the first was oral, and the latter was lost. The present paper is intended to be a concise and authoritative statement of the contents of the two papers and as a substitute for them.

In the Lyceum communication I proved that the so-called ammonium amalgam is in fact no amalgam at all, but a metallic froth of which the liquid part is mercury and the gaseous part a mixture of hydrogen and ammonia. This conception of the nature of the substance was at that time not altogether novel, but the considerations through which the conclusion was reached, were believed to be new and of such moment that taken together they have the effect of a demonstration. The considerations were these:

1st. In the formation of ammonium amalgam the mercury is increased in bulk tenfold or more, while in weight it is increased only one or two thousandths. This fact would be easily predicted by the froth theory while otherwise it is anomolous and utterly inexplicable.

2d. Ammonium amalgam has less of the mirror surface than mercury; it approaches in appearance the whiteness and lack of lustre of mat silver. This fact also finds a satisfactory explanation in the froth theory.

3d. Ammonium amalgam is readily compressible; when confined in a fire syringe it steadily contracts on forcing down the piston till the original bulk of the mercury is almost reached, and on re-

lieving the pressure the original volume and appearance are resumed. It is only a froth which behaves in this manner.

Either (1) or (3) will be conclusive to many minds; (3) is put forward as a fair *experimentum crucis*. The condensation by pressure is easy to execute, and an elegant experiment for the lecture-room. The condensation is somewhat greater than in the case of atmospheric air for the reason that some of the ammonia gas goes into the liquid state.

Having concluded that the ammonium amalgam is a mercuric froth, a very important question presents itself: Why and how do metal and gases become mingled? A froth is a mechanical mixture, and in all ordinary cases the manner of mixing and the forces engaged are quite evident. In the formation of the mercuric froth, the mercury covered by a watery solution rises up spontaneously into the comparatively light water, and the still lighter gases descend into the mercury and mingle with it until they become diffused through its whole mass. What are the forces which thus overpower the action of gravity? Moreover, a froth implies a certain viscosity or plasticity of the liquid which seems not to be possessed by the mercury in its normal condition. Do hydrogen and ammonia in their nascent state have the power to modify the physical properties of mercury? The production of mercuric froth as a fact of physics simply may seem anomolous and paradoxical. Is it necessary after all to admit the existence of an ammonium amalgam, not of course as a constituent of the mercuric froth, but as a condition precedent of the formation of the latter,—in other words, of another ammonium amalgam to satisfy a new theory?

I was making satisfactory progress in the investigation of the theory of mercuric froth when, early in May, my attention was diverted to the researches of Weyl on ammonium and compound ammoniums as reported in *Watt's Dictionary* (article, Sodium), and in the last edition of *Fownes' Chemistry;* subsequently, I compared Weyl's original memoirs in *Poggendorff's Annalen* of 1864. Weyl's statements and conclusions were quite at variance with my own views; his alleged facts were inconsistent with my own experience. Weyl, it appeared, had actually isolated ammonium; if he represented the facts correctly all my work needed revision. I therefore at once devoted my whole care to a verification of his results. I repeated his experiments, some of them many times, and with such precautions, modifications and additions as the

case seemed to require. The result of all is that I find that Weyl has had only an imperfect apprehension of the fundamental facts, and that thus building on a weak foundation the superstructure of reasoning and conclusion cannot stand. For the purpose of presenting in a clearer light what I suppose to be of more interest to the chemical world, I dismiss, for the time, the consideration of Weyl's views, and I proceed to give what in my judgment are the proved physical and chemical facts.

This discussion involves the relation of ammonia to the alkali metals, and the results which grow out of that relation. Now, the key to the whole subject is the fact that liquid anhydrous ammonia is a solvent, without definite chemical action, of the alkali metals. I mean that these metals dissolve in the ammonia as salt dissolves in water,—the solid disappears in the liquid, and on evaporating the liquid, the solid reappears in its original form and character. There is no definite atomic action in any such cases; the components of the solution are not changed in their chemical relations to other substances.

I began my experiments by bringing together ammonia and the metals in sealed inverted U-shaped glass tubes. Chloride of silver saturated with ammonia was placed in one leg of the tube, and the metal under test in the other; the chloride of silver leg being immersed in boiling water, and the other in ice-cold water, the ammonia was liberated and passing over was gradually condensed on the metal. Such an arrangement, although sufficient to demonstrate the fact of the solution of the metal, proved inconvenient in several respects; the tube is liable to burst, the experiment can be made only on a pretty small scale, the chloride of silver does not absorb a desirable amount of ammonia, and by reason of its fusing or agglomerating, the rapidity of its absorption varies greatly. I therefore constructed an ammonia generator or retort of iron, to the horizontal neck of which turned downward at its end, I attached by means of an iron screw coupling the stout glass tube containing the metal or other substance to be subjected to the ammonia. In the place of the chloride of silver I substituted anhydrous chloride of calcium saturated at 32° Fahr. with anhydrous ammonia. With this arrangement the experiments were continued with comparative ease and expedition.

When sodium is subjected in this apparatus to the condensing ammonia, before any ammonia is visibly condensed to the liquid

state, it gradually loses its lustre, becomes of a dark hue, and increases in bulk. The solid then appears to become pasty, and at last we have only a homogeneous mobile liquid. During the liquifaction, and for a little time after, the mass is of a lustrous, copper-red hue; the condensation of the ammonia and its mingling with the liquid steadily goes on, the liquid is progressively diluted, and passing through a variety of tints by reflected light at last it becomes plainly transparent and of a lively blue as well by reflected as by transmitted light; the liquid now closely resembles a solution of aniline blue or other pure blue dye-stuff. On reversing the process by cooling the ammonia generator, the ammonia gradually evaporates out of the liquid, and the changes observed during the condensation reappear in the reverse order, till at last the sodium is restored to its original bright metallic state. If the evaporation be conducted slowly and quietly the sodium is left in crystals of the forms seen in snow. The formation of the transparent blue liquid, and the restoration of the sodium are steadily progressive, and the repeated and closest scrutiny of the process has failed to reveal the slightest break or irregularity in its continuity. The inevitable conclusion from such facts is that the blue liquid is a simple solution of sodium in ammonia, not at all complicated or modified by any definite chemical action.

If crystallized sodium amalgam be made to replace the sodium in the experiment it remains unchanged although it is probable enough that at a higher temperature or with a larger excess of sodium, some of the sodium would be removed. This interesting fact is consistent with the simple solubility of sodium in ammonia, and indeed is some confirmation of it. The force, whatever it be, which keeps together sodium and mercury is certainly weaker than that exhibited between sodium and ammonia. If sodium amalgam is not a definite chemical compound, then surely the blue liquid cannot be. I have not yet made the experiment to determine whether mercury will remove sodium from its ammoniacal solution, but it seems extremely probable that it would so act.

The brilliant and varied colors exhibited in the experiment may seem anomalous to some, when, in fact, a closer scrutiny of the case will show that they might have been predicted. Sodium appears white to the eye, but with the white light reflected from its surface to the eye, there are always mingled red rays. If most of the incident white light were normally decomposed, sodium would appear

as a brilliant red metal. Ammonia favors such a decomposition probably by reducing the density and opacity of the surface, and thus the concentrated solution of sodium is lustrous copper-red by reflected light. What should be the color by transmitted light? Not red, for the red rays do not penetrate the substance; the color must be looked for in that which is complementary to red; it must be blue or yellow or combinations of these. A continuance of the argument will bring the conclusion that the color by transmitted light will be blue. Intense blue tinctorial substance, like aniline blue, indigo and Prussian blue, all illustrate the phenomena of color of the sodium solution; they are metallic red when concentrated, and if the solvent be applied in vapor as in the sodium dissolving experiment, there will be the same modification of color exhibited. Sodium has a remarkable tinctorial power which seems not to be surpassed by that of any of the aniline colors.*

If a salt of a metal electrically negative to sodium be subjected with the sodium to the ammonia, in the apparatus, the sodium will replace the negative metal, and the latter will be reduced to the simple state. This reduction seems always to be accompanied with the evolution of heat, but does not commence till a visible quantity of the sodium solution is formed. It is possible that there may be exceptions to these generalizations. I need only say that they seem extremely reasonable, and are confirmed by a good many experiments. The reaction furnishes a very simple and elegant process for the reduction of rare metals. I anticipate that the process will prove of great value.

I have heretofore spoken of the solution of sodium only, for the reason that it is a typical case, and because demonstrations can be more satisfactorily made with it. Potassium behaves towards ammonia in almost precisely the same way. It is readily dissolved, the strong solution being copper-red and the diluted solution blue. Lithium gives also a blue solution, but is not nearly so soluble. The only other alkali metal I have tried is rubidium, and although the experiment was prematurely ended, it had progressed far enough to make it almost certain that rubidium is soluble like potassium, and I intend, as soon as I can procure material, to repeat the rubidium experiment.

Besides the metals named, I have subjected many others to the ammonia, and have found none outside of the alkali metals which are in the least affected. I have directly tried aluminium, magnesium, thallium, indium, mercury and copper.

* For a further elucidation of the matter of this paragraph I would refer the reader to my paper on the "Colors of Metals," printed in the proceedings of the Lyceum of Natural History, of New York, of October, 1870.

Chemical Laboratory, 26 Pine Street, N. Y.

A NEW FORM OF SOLAR EYE-PIECE.

By Prof. S. P. Langley.

Of late years, a form of solar eye-piece has been generally used in which a plane reflector of unsilvered glass is placed between the eye-lens and the objective, and at an angle of 45° with the axis of the cone of rays from the latter.

About six per cent. of the light is reflected to the eye, and the remainder transmitted or absorbed by the glass, whose posterior surface is so inclined to the first as to avoid any interference from secondary reflection. The rays thus weakened are further absorbed by a dark glass, which may be of comparatively light tint as compared with that necessary for the direct beam.

More recently it has occurred to many beside the writer, that the introduction of a second reflector would permit a radical improvement, by giving the power to polarize the beam. Solar eye-pieces on this principle, employing as many as four reflections, have been constructed in Munich, and others, with two or more, have been made in this country, by Mr. Tolles, of Boston.

I have not seen any of these instruments, but having been at some pains in the construction of one which cost a good deal of experiment, I hope that this description may be useful to any one who wishes another. The theory of the instrument is too simple to need much explanation.

Since the polarizing angle depends on the refractive index of the glass, for the ray, with sunlight a part of the spectrum, must remain unpolarized, which is greater or less, according to the dispersive power of the medium employed for the reflectors; for these should, of course, be chosen some glass of moderate dispersive power. Let this be plate glass, and let it be assumed that its index or refraction for some ray near the green, or most luminous part of the spectrum, is 1·525. Then, by the use of a familiar formula, we find that the angle of incidence at which this ray will be completely polarized is 56° 45′. The reflectors should then be cut, so that their faces may present a section of the cylinnder, made at an angle of 33° 15′ with the axis. The essential condition to secure, will, however, be that the reflecting surfaces are optically perfect planes, and the successful use of the instrument presupposes the best work in this particular.

The second surface may be plane, and inclined at a suitable angle to the first, or worked (as suggested by Sir John Herschel for a similar purpose) to a concave figure; the secondary reflection being in either case avoided.

When the reflecting planes are parallel, about eight per cent. of the light incident at the angle of maximum polarization is received from the first surface, and eight per cent. of this fraction from a second. With three such planes, about $\frac{1}{2000}$ of the incident light is reflected. It is significant of the intensity of the solar radiation that the light thus diluted two thousand times is still intolerably bright. The beam is supposed here to be still unpolarized, but as the polarization is in any case but partial, it becomes a question how many reflections are necessary, and this can only be decided by trial. In my experience, two are not enough to give the best results, as with the least dispersive material that can be chosen for the prisms, enough light remains after polarization to fatigue the eye. Four are unnecessary, since I find that with three the light may be enfeebled, till the eye finds it difficult to recognize the details of the solar surface.

It remains to describe the manner in which these are used.

If the rays concentrated by a large object-glass fall centrally on the first reflector, it will heat equally, and be in little danger of injury, but if it be placed so that these rays are only on part of it, (which will generally be the case in examining the limb of the sun) a fracture of the glass is not unlikely to result. The actual loss of one in this way led me to the construction finally adopted, which is nearly this: The first reflector is to be larger than the greatest diameter of the solar image in the telescope to which it is applied. It is fixed in position and direction, and the rays from the sun being brought centrally on it, are kept there by the clock-work of the equatorial. The second and third reflectors have a common motion independent of the first, by which they are enabled to receive centrally the rays from any part of it. This is effected by mounting both on a mechanism like the stage plate of large microscopes, while the third reflector has a motion of rotation about the line joining its centre with that of the second.

When the three planes are parallel, the light is enfeebled by reflection only, but when, in addition, the third is turned through an angle of 90° from this position, the light of the sun, even when received from the full aperture of a 13-inch lens, emerges free from

adventitious color, and of scarce sufficient intensity for the ready observation of details. It is, of course, only necessary to turn the prism through more or less than 90° to obtain every gradation of light up to dazzling brightness, and this extreme facility of control is not the least advantage of this form of eye-piece.

The instrument I have described may be constructed at less cost, by omitting the independent motion, which has been described as carrying the second and third reflector above the first. These may, if retained, have a graduated index, and readily serve as a sufficiently accurate micrometer for ordinary work on the sun, or they may be wholly discarded. The instrument will be effective without them if sufficient care ensures that the first reflector is not broken by the heat, and in this form is easy of construction, and need be of only moderate cost.

ON THE RECTIFICATION OF PETROLEUM.

By Prof. Edward Parrish.

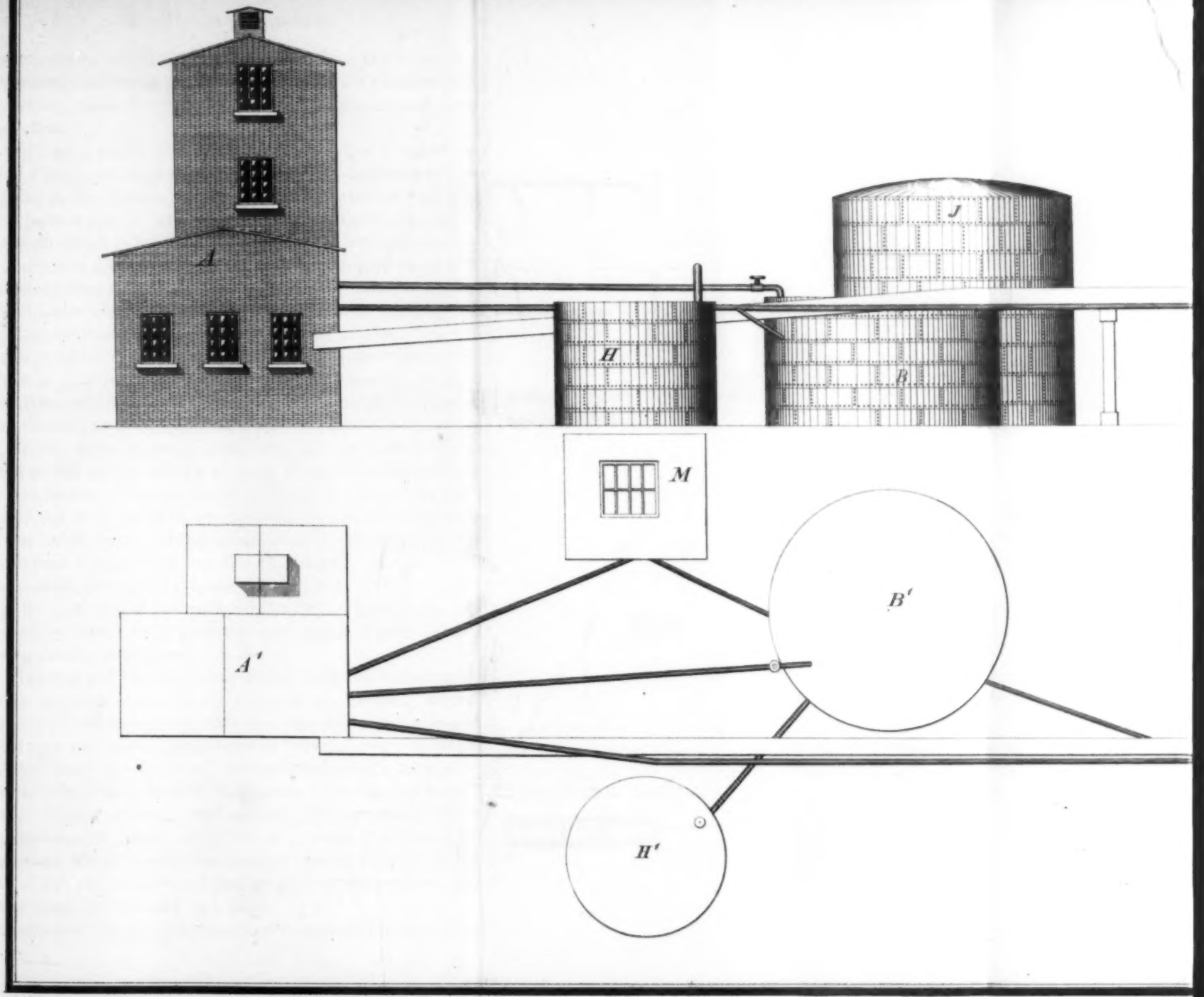
In the course of some investigations upon the petroleum products known as Benzine and Gasoline, I was led to visit one of the leading establishments in Philadelphia in which they are produced, and not being aware of any illustrated description of the process of fractional distillation and rectification as actually practised, determined to obtain the necessary data and drawings for a paper in the *Journal of the Institute*. The establishment referred to is that known as the Franklin Oil Works, belonging to John L. Stewart, located at Gibson's Point, on the Philadelphia, Wilmington and Baltimore Railroad, about a mile below Gray's Ferry, and very near the terminus of the Branch of the Pennsylvania Railroad over which petroleum is brought to the Schuylkill river for shipment. At this point large underground reservoirs exist, into which crude petroleum is run, through pipes, directly from the oil cars in which it is brought from the wells; from these it may be readily transferred to metallic reservoirs on shipboard, or into the receiving reservoirs of the several refineries in the vicinity. The refined kerosene, barrelled for shipment, is also transferred, with very little handling, to vessels lying at the adjacent wharves.

The annexed drawing, by E. Parrish, Jr., C. E., was sketched from the Philadelphia, Wilmington and Baltimore Railroad, on the west side of the works. The entire length of the inclosure is 700 feet, and in the drawing no attempt is made to adhere to a scale, or to represent the whole extent of the establishment. The leading idea in the distribution of the several parts is to secure safety from fire, the chief storage of material being near the northern, and the apparatus requiring fires near the southern end.

In the frame building, A, there are four pumps worked by steam. One of them is for pumping water, one crude petroleum, one kerosene, and one for forcing a powerful current of air into the rectifier and into pipes communicating with the several reservoirs and the still. By these pumps the crude petroleum is transferred from the receiving tank to that marked B in the drawing, and thence, as required, to the still, and the main portion of the distillation is sent to the rectifier, thence to the bleaching house, and thence to the large tank, J, all without labor, loss by evaporation, or danger from fire. The still, C, is located at the southern end of the inclosure; it is of wrought iron, with steel bottom, and holds a charge of 19,000 gallons. It is inclosed by brick work, in which are eight furnaces; this reaches to within about six feet of the top, which is somewhat drum-shaped, and has two necks, through which the vapor is conveyed to the cooler.

Besides these, which carry off the more volatile vapors, there is a pipe inserted lower down in the still, which conducts the heavy lubricating and paraffin oils coming over toward the end of the process through the worm and tub, *d*, to an iron receiver, *d d*. To aid in collecting these least volatile products, which are, for the most part, condensed in the top of the still, a ledge extends around the inside, just at the point of insertion of this pipe. The fuel burned under the still consists of bituminous coal mixed with the tar and coke left as residuum from the process; these resemble coal-tar and asphaltum, though nearly without odor.

The main cooler consists of several courses of iron pipe, running horizontally through a closed wooden trough, eighty feet long, into which a stream of cold water is conveyed by a pipe shown in the drawing, from near the top of the adjacent building, in the basement of which there is a pump for its supply. The inclination of this water-pipe causes it to empty itself whenever the pump ceases to act, thus preventing its bursting when out of use, by freezing. Surmounting


A
J
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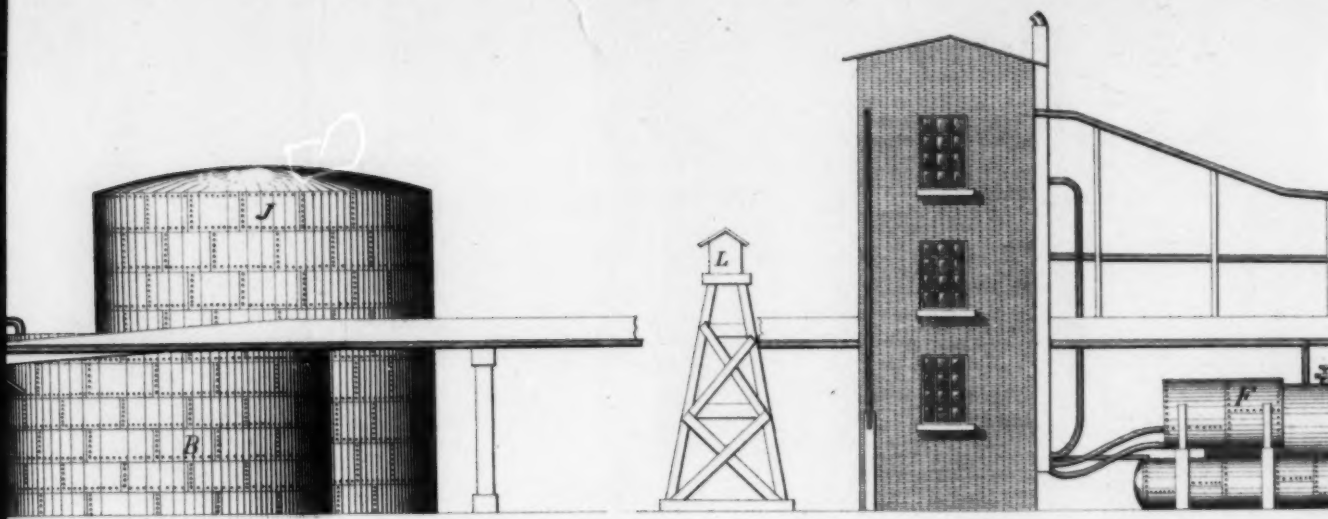
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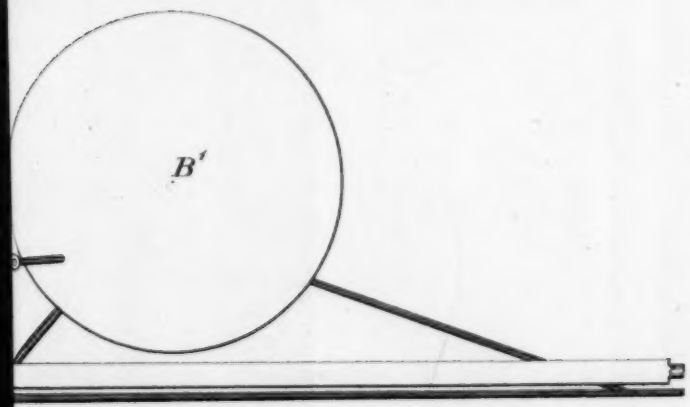
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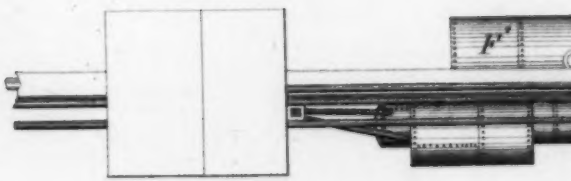
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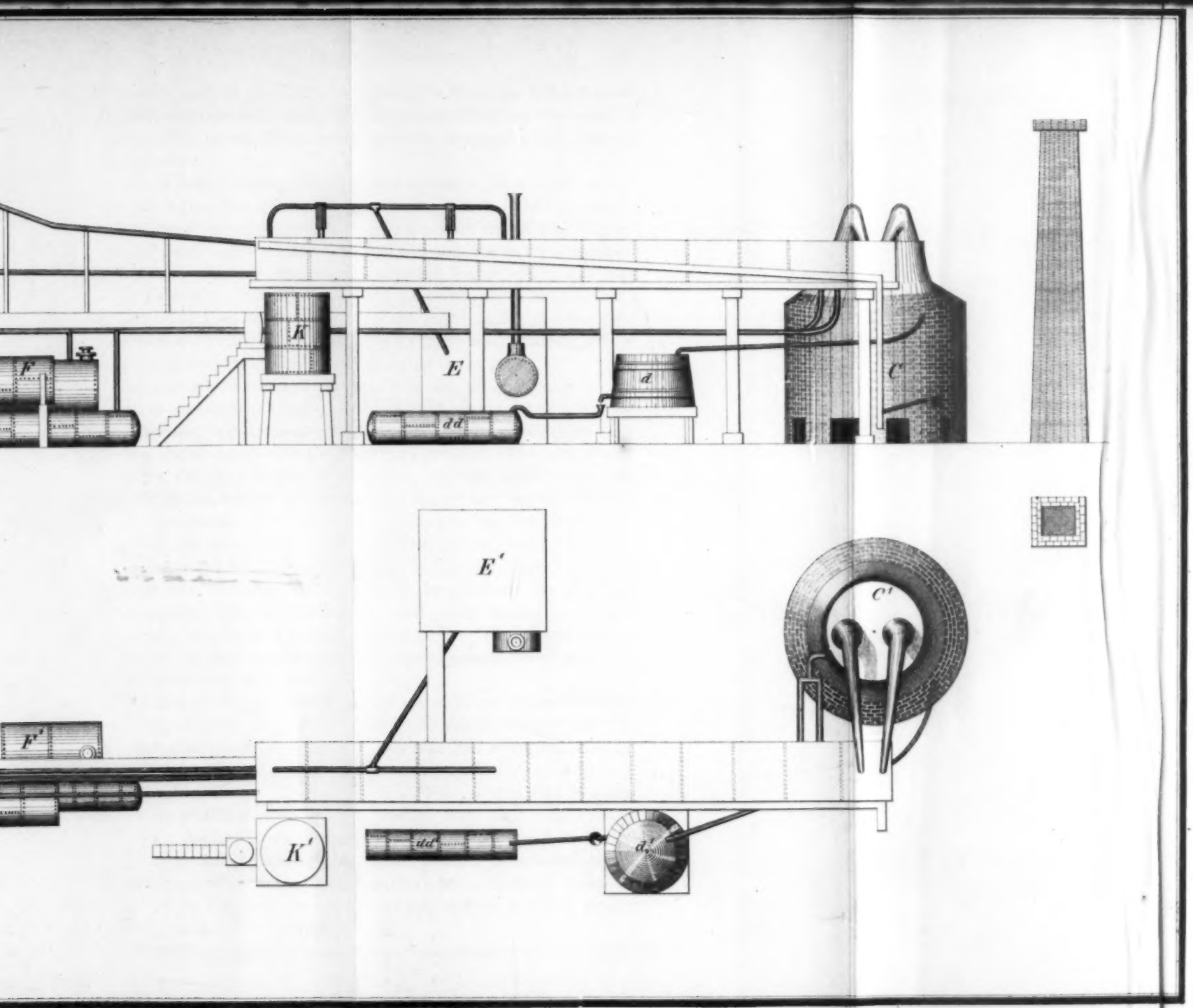
K
F
E
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the cooler, several small vertical pipes arise from the lower line of the horizontal condensing pipes, for the escape of the non-condensable vapor, which passes off, especially near the beginning and close of the operation.

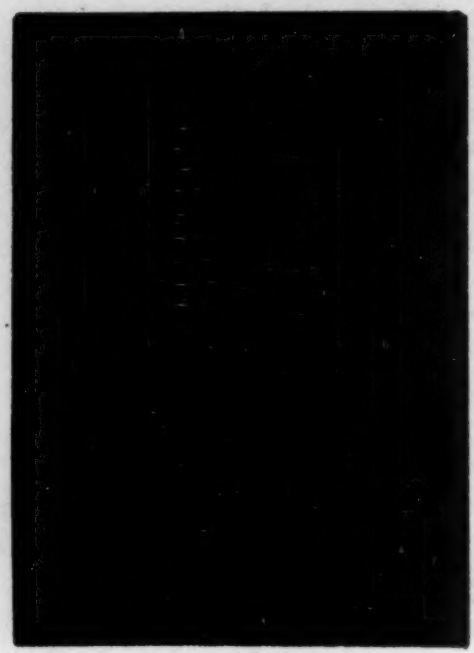
As this heavy vapor, when allowed to escape, is a waste material, and a frequent cause of conflagration, it is desirable to collect and utilize it, for which purpose, over the open end of each of the vertical pipes a pipe of larger bore is set, and these are connected with a main which is led into the adjacent boiler house, E, where a jet of steam is discharged into it in the direction of the fire box, a draft being thus created, by which the highly inflammable vapor is carried under the boiler, and by its combustion made to aid in generating the steam required for working the pumps.

The pipe which conveys the steam to the distant pumps is inclosed in an elevated wooden trough, filled with sawdust to prevent condensation, and this is also used for the support of the pipes connecting the air-pump with the reservoirs and still. The other pipes, used for the conveyance of petroleum, are not buried, but laid directly on the surface of the ground, where any leakage may be easily discovered. The tall frame building to the left of the terminus of the main cooler is appropriated, on the lower floor, to a pump, as before stated; on the second floor is the separator, which is a cast iron box, open at top for the reception of the distillate, and connected, through the bottom, with pipes leading to the receivers for benzine and kerosene respectively. Here these liquids are tested by their specific gravities, and separated previous to undergoing further treatment.

The benzine and gasoline receivers and stills are located near this building, on either side. One is shown in the drawing, marked F. A steam pipe passes into this still, and the still communicates by another pipe with a refrigerated coil in the third story of the above mentioned building. This coil is constructed with a view to separating the distillate to be sold as gasoline from that to be sold as benzine. A pipe leaves the coil midway, through which the more easily condensable portion of the mixed product is collected, while the gasoline, which is only condensed by passing through the entire length of the coil, is delivered into an appropriate receiver, mostly under ground, and covered by a shed.

The annexed figure represents the arrangement for separating the

gasoline. The still, F, which is heated by a coil of steam pipe, connects with a wrought iron stand pipe, 10 inches in diameter, 30 feet high, which conducts the vapor into the worm and cooler. The pipe A conducts back all that condenses in the stand pipe, and the pipe B all that condenses in the first 100 feet of the coil. The water in the cooler, from the line D to the top, is kept at about 80° F., and below that point as cold as possible, not above 60° F. Only the vapor passing this line is fit for gasoline; E is a gas trap, with glass sight-holes; F an escape-pipe for uncondensed vapor.



Following the line of pipe from the separator, and passing the crude petroleum tank, B, we come to the receiving tank for the great body of the distillate, H. The portion designed for kerosene being received here, is transferred to the refinery in the upper part of the building A. This consists of an open wrought iron boiler, lined with lead, in which 225 barrels of the distillate are agitated with ten carboys of sulphuric acid, by means of atmospheric air forced in at the bottom. A strong odor of sulphurous acid is given off during the ebullition, and the kerosene is found to have lost an objectionable adhesive property, and to be less liable to "gum."

Great care is necessary thoroughly to wash out the acid by subsequent continued agitation with water, and lastly with soda. The air-pump being now shut off, the oil rises to the surface, and is drawn off to the bleaching house, which is a large shed, M, shown in the ground plan, having a roof partially of glass, and covering an open tank about 25 feet in diameter. Here the kerosene is exposed to the sun's rays and to a temperature somewhat above 110°

F., produced by a steam pipe, which is protected from direct contact with it by a three-inch cast iron pipe, in which it is inserted. The effect of ten thousand gallons of this brilliant liquid, with the sun shining directly upon it, is most striking; the refraction of the light gives to the bottom of the tank the appearance of a constantly changing concavity with the greatest apparent depth nearest the point of observation. The opalescence or fluorescence is superb, though, with the exception of this effect, the freshly distilled, rectified and bleached liquid may be said to be colorless.

From the bleaching house the kerosene is forced, by the appropriate pump into the tank, J, not shown in the ground plan, whence it is drawn for barrelling, an operation performed in a large building, omitted from the drawing, supplied with every convenience for its rapid and economical execution.

All the petroleum products are sold in barrels, which are painted blue; each barrel holds about forty-four gallons. But the kerosene is sold by weight, six and a half pounds being the weight of a gallon, and the net weight of each barrel is marked on the outside, by cutting through the paint.

An ingenious automatic faucet is used for filling the barrels; this being inserted tightly into the bung, the escape of air is through it, and as soon as this ceases, from the barrel being full, a leather diaphragm subsides and releases a cut-off held by a cord, so that the flow of the liquid stops.

It remains only to mention two other features of the works represented in the plan. The agitator, K, receives the refuse and any portions of the distillate unsuited to go into either of the finished products, that it may be mixed, and prepared to be returned to the still. The lantern, L, is so elevated as to be removed from escaped vapors, which are apt to collect near the ground; when lighted, it throws a strong light into the separator, a part of the apparatus which it is very necessary to inspect and adjust at night, as well as by daylight.

There are several other buildings; an office, shops, stables and sheds, such as appertain to most factories, which are not represented in this drawing, the object being to convey to the reader an idea of the essential features only, of a petroleum refinery.

The drawing and description of these works has been made without reference to additions now in progress. A large and greatly improved still and cooler are in process of erection, and the pro-

prietor, who is himself the inventor of some improvements, like most successful manufacturers, shows a laudable desire to excel in the completeness of the apparatus and the perfection of the products.

After this description of the apparatus, it will be appropriate to refer more particularly to the process. Twice a week a charge of the crude oil is forced into the still. The fires are then kindled, water turned on to the main cooler, the jet turned into the gas pipe communicating with the fires under the boiler, and the pipes connected with the separator arranged to collect the parts of the distillate designed to be converted, by fractional distillation, into benzine and gasoline. According to my friend, B. J. Crew, who has had experience in this process, crude petroleum gives off nearly incondensable vapor from 60° to 160° F.; from 160° to 280°, the benzine or naptha comes over; from 280° to 600°, the oil suited for illumination; and above 600°, paraffine oil.

During the early part of the process, the specific gravity of the condensed material is taken, from time to time, at the separator, and when it reaches 85° Beaumé the pipe communicating with the gasoline receiver is closed, and it runs into the benzine receiver until it reaches 66° Beaumè, after which it passes on to the large distillate receiver. Sometimes the heavier portions of the benzine is returned to the still, and is thus mixed with the kerosene distillate in the subsequent part of the process, and if there is no market for gasoline, this may also be returned, and may add to the uncondensed vapor consumed under the boiler, and, perhaps, to the available condensed products.

The proportion of the several products may be stated approximately as follows: Gasoline, 8 per cent.; benzine or naptha, 12 per cent.; paraffine, or lubricating oil, 5 per cent., and the remainder is kerosene. The fixed residuum varies in quantity and consistence with the persistence of the operation and the quantity of the crude oil; from one charge of 19,000 gallons an average of about 6½ barrels is obtained. The temperature and mode of conducting the process, however, modify the proportions of the several products. If, toward the last, the heat is pushed, destructive distillation of the tarry mass ensues, and incondensable and difficultly condensable vapors come over, at the expense of the residuum, and it is probable that petroleum tar, like coal tar, yields, at a high heat, a portion of oil suitable for burning.

This essay has already reached its proper limit, and our observations on the uses and properties of the products of this important process of fractional distillation must necessarily be omitted.

ON SOME OF THE CONDITIONS OF LOSS BY VOLATILIZATION IN CERTAIN METALLURGICAL OPERATIONS.

By CHARLES P. WILLIAMS, Prof. of Chemistry, etc., Delaware College.

IT is a well recognized fact, pointed out by an expensive experience, that in all methods of lead smelting and in oxidizing and chloridizing roastings generally, a very considerable loss of metals results. This loss is brought about either by the formation of more or less volatile compounds, or by the draught of the furnace carrying, mechanically suspended, particles of chemically changed ore, with the products of combustion, or, in the case of muffle furnaces, with the atmosphere sweeping over the ore therein treated. The problem of devising an economical and complete method of collecting these metallic vapors or fumes is one of very considerable difficulty, and it may be fairly questioned if it has yet received a satisfactory solution. In this country where rich lead ores are abundant, and where all the elements, except labor, entering into the metallurgical treatment of such ores are comparatively cheap; this matter of condensation and collection has not generally forced itself upon the attention of practical metallurgists, but it is nevertheless of considerable significance.

In the treatment of silver-bearing ores by smelting operations, or where a previous chloridizing roasting is necessary, the loss of silver by volatilization must be of significant importance and will yet, if it has not already, give rise to a study of the means adapted to its prevention. Various European experimenters have given different figures for the loss of silver by volatilization in different methods of its extraction, but these figures may safely be averaged as ranging between 0·5 and 4 per cent. of the content of the original ore. With regard to chloride of silver it is well established that its volatility is greatly increased by the presence of other chlorides. Plattner's experiments on the Augustin method of silver extraction,* show that a mixture of 10 parts of oxide of copper, 3 of chloride of lead and 0·6 of fused and finely divided chloride of silver, lost, on roasting in a current of air, 6·61 per cent. of the original weight by volatilization. The sublimate, on quantitative examination, gave 63·8 per ct. chloride and oxide of lead, (containing 54·8 of metallic lead), 32·8 per cent. of cuprous chlor-

* *Berg-und Hüttenmänische Zeitung*, 1854, p. 125, *et. seq.*

ide, (containing 21 of copper,) and 3·4 of argentic chloride, (containing 2·6 of silver). These figures would give 5·09 as the per centage of the loss of the chloride of silver contained in the original mixture, partly due to the volatility of chloride of silver itself, but chiefly brought about, however, by the presence of other chlorides. In the oxidizing roasting of sulphuretted compounds of silver, the loss is also great, through the volatilization of the sulphate, etc., of themselves, or increased by the presence of compounds of other metals, or through the mechanical movement of fine particles of the ore by the draught through the furnaces.

In the treatment of galena for the extraction of lead, whether by the process of reaction or by other means, a large amount of the metal is lost, chiefly in the forms of sulphate or of oxide. This loss, though admittedly large, is not fully appreciated, and is, without doubt, due, not merely to the volatility of the oxide of lead, (this being partially changed into sulphate,) but also to the facts that sulphate of lead is volatile, and that sulphide of lead is readily and rapidly volatilized at elevated temperatures and is subsequently converted into sulphate either through the action of the oxygen of the air or through that of sulphuric acid. This latter production of sulphate is well established by the researches of Plattner,* and his observation of pseudomorphous crystals of plumbic sulphate after sulphide of lead, which had formed after the condensation of the latter crystals from a vaporous condition. The writer of this communication has invariably observed during repeated exhaustive analyses of the so-called Bartlett White Lead, and of oxide of zinc produced at the Keystone Zinc Works, the presence of sulphide of lead. Both of these substances are essentially mixtures of oxide of zinc and plumbic sulphate obtained by the treatment of mixed galena and blende by the well-known process for the manufacture of zinc white directly from the ores. On treatment with hyposulphite of soda the sulphate of lead is readily dissolved, whilst a subsequent addition of dilute acetic acid will dissolve the remaining ingredients, leaving a small amount of dark metallic particles, which, on chemical and microscopic examination, are found to be minute crystals of sulphide of lead.

Mr. Geo. T. Lewis, a well-known manufacturer of this city, has repeatedly completely volatilized several hundred pounds of the purest galena obtained in the Wisconsin lead region. The pro-

* *Procedes Metallurgiques de Grillage*, p. 207, *et, seq.*

ducts of these treatments, (which were chiefly conducted in the Wetherill furnace for the manufacture of zinc white,) were collected by the "bag process," and have been analyzed by the author. They are mixtures of sulphate of lead, (commonly about sixty per cent.,) with some oxide of lead and zinc, and carbonate and sulphite of lead, and invariably contain small and variable amounts of sulphide of lead.* From these experiments the high degree of volatility of this last named compound must be admitted, unless it be claimed that it is first converted into sulphate, and that this salt is even more volatile than the sulphide. The author has made efforts to establish the degree of volatility of the sulphide of lead by strongly heating the artificially prepared salt in currents of nitrogen and hydrosulphuric acid, but has found so many difficulties in the preparation of a perfectly dry and unaltered compound that he cannot, as yet, regard his results as removed beyond sources of fallacy.

Plumbic sulphate is also to a slight degree volatile. Some of the perfectly dry and pure artificially prepared salt was strongly heated for one hour in a porcelain tube through which a current of dry air, freed from carbonic acid, was drawn. Thus treated, 1·4082 grammes of the sulphate lost in weight ·0019 grammes, equivalent to 0·134 per cent. A second experiment with 4·2761 grammes, but heated for upwards of two hours, showed a loss of 8·5 millegrammes, or a little less than 0·2 per cent. Other trials showed variable losses, but in no instance was the percentage amount greater than that obtained in the second experiment. Examined with a glass, indications of fusion of the sulphate were noticed. That this method of producing sulphate of lead in lead smoke or fumes is of much moment compared with that of the volatilization and subsequent oxidation of the sulphide, can hardly be claimed, though it doubtless is one of the many causes of the loss of lead in metallurgical operations.

Another cause of loss is the mechanical one brought about by the currents of air or of the products of combustion sweeping through the furnaces. In furnaces of that description where the fuel is intermingled with the ore under treatment, or where the gases, vapors, etc., from the fuel in the fire box pass over and in contact with the charge, this mechanical loss is doubtless increased

* The method of analysis followed in these investigations was essentially that described by the author in this *Journal* for March, 1869.

by the presence of fuliginous particles of finely divided carbon which enclose, and, as it were, buoy up the denser particles of metallic compounds. Where the metallurgist has to deal with lead ores which contain zinc compounds—by no means an unusual condition of affairs—it will be admitted that the formation of zinc vapors and their subsequent conversion into the specifically light oxide of zinc, will add greatly to the loss of lead as sulphide or as oxide by assisting mechanically in carrying these compounds from the furnace in a manner similar to that in which the sooty particles of carbon may act. The volatility of silver as oxide or as sulphate may be fairly assumed as increased in this same manner. The experiments of Malaguti and Durocher,* made with argentiferous zinc blende, indicate that the loss of silver in the presence of zinc compounds may be very considerable, reaching as much even as 70 per cent. of the original content of the ore, but ranging usually according to the richness of the ore in silver and in zinc, and according to the management of the furnaces, between 15 and 66 per cent.† A small proportion of this loss is unquestionably due to the volatility of the sulphate of silver, but, as in the case of ores not carrying zinc, and not highly silicious, the loss is less than 10 per cent,‡ it must be admitted that zinc compounds dispose silver to volatilize.

The ores mined in the Silurian lime-stones of Sinking Valley are chiefly intimate mixtures of zinc blende and galena, (the latter forming usually about 20 per cent. of the mixture,) and contain on the average, by the assays of the author, about five ounces of silver to the ton of 2000 lbs., though Ashmead finds§ by his assays 8·5 and 9 ounces. These ores are treated, at the Keystone zinc works, for the manufacture of zinc white by the ordinary process, and in the residues on the perforated grate bars of the furnace, the writer has never been able to find weighable quantities of silver, though operating repeatedly on amounts of 58½ grammes. By dissolving a weighed amount of the so-called "oxide" made from this ore and collected in the "bags," in nitric acid, evaporating to dryness, adding hydrochloric acid, extracting with water and assaying the residue in the usual manner, 0·014 per cent. of silver may be found,

* *Annales des Mines*, XVII., 1850.

† Plattner, *loc. cit.*, p. 118.

‡ Kerl's *Handbuch der Hüttenkünde*, I., 2d Edition, p. 89.

§ *American Chemist*, Vol. I., No. 4, p. 134.

corresponding to 4·2 ounces to the ton of "oxide." The "Bartlett White Lead," prepared in a similar manner from mixed blende and galena, mined in Davidson county, North Carolina, yields a somewhat smaller percentage of silver, (0·0087 per cent.,) though the original ore is more highly argentiferous than that utilized in Pennsylvania. This discrepancy may be accounted for, however, by the fact that the North Carolina ore is roasted (with the addition of salt?) at the mine before shipment to New Jersey for its conversion into the basis of a pigment.

The following analyses will exhibit the composition of lead fumes by various operations:

	No. I.	No. II.	No. III.	No. IV.	No. V.	No. VI.
ZnO	72·083	73·426	49·50	13·80	25·70	9·23
PbO	·274	.....	27·90	10·20	48·30	13·21
SbO_3	trace.	.....	AsO_3 2·10	.....	3·90	.....
Fe_2O_3	"	.....	.....	3·40	.....	trace.
PbO SO_3	23·958	25·084	13·00	66·60	14·40	74·05
Zn OSO_3	·810	·574	.....	PbS. 1·40	.....	trace.
Zn Cl	·839	.....	.....	.....	.....	.....
Fe_2Cl_3	·071	.....	.....	.....	.....	.....
$Sb Cl_3$	trace.	.....	.....	.....	.....	.....
Cd Cl	·256	.....	.....	.....	.....	.....
CdO SO_3	.....	·187	.....	.....	.....	.....
CaO CO_2	..... and	loss ·729	CO_2–7·00	.....	4·50	3·27
Clay	.....	.....	.....	5·60	.....	SO_2 ·84
Per cent. Pb in above	16·624	17·132	34·778	56·169	54·571	62·840
Ag	0·0087	0·014	.....	.....	.....	·0019

Analyses I., II. and VI. are by the author; III., IV. and V. are from Watt's Dictionary of Chemistry, Art. Lead. No. I. is the so-called Bartlett White Lead, (this *Journal*, March, 1869); II. is the zinc white from the ores of Sinking Valley, Pennsylvania; III., fumes from blast furnaces at Freiberg; IV., fumes from reverberatory furnace at Alston Moor; V., from refinery at Freiberg; VI., from Wisconsin ores treated at Birmingham, Pennsylvania, in the Wetherill furnace for the manufacture of zinc white; Nos. I. and II were also obtained by treatment in the same furnace. The three analysed by the author all contained sulphide of lead, but the amounts were small and were not estimated.

Estimates based upon the treatment of a large amount of ores have given the following figures, making evident the loss in the

treatment of lead ores by conversion into merchantable lead, though unfortunately no descriptions of the characters of the ores are furnished: A blast hearth furnace treating 267,008 pounds, yielding by assay 75·75 per cent., or 202,258 pounds, gave 178,895 pounds or 67·00 per cent, exhibiting, therefore, a loss of 23,363 pounds. The refining process gave a further loss of 13·40 per cent, whilst the reduction of the dross from the refinery added a still further loss of 3·60 per cent., giving an aggregate of more than 28½ per cent. of the original content of lead.*

If considerations of the health and property of a neighborhood are only of subordinate importance, such figures must make evident the necessity of connecting, with lead establishments, suitable apparatus for the condensation and saving of this fume. The process of straining the fumes through muslin or fine canvass, which gives such successful results in the collection of zinc fume or oxide as exemplified by the well known "bag process," has not received from metallurgists the attention its simplicity and completeness merit. From experiments made on a large scale on galena ores, both nearly pure and containing a large amount of blende, the writer is satisfied that its application to the condensation of lead and other metallic fumes would leave little to be desired. It seems strange that it has not been applied to purposes other than the mere saving of oxide of zinc, especially when the necessity of a thorough collection of metallic fume is considered. Its satisfactory use in the treatment of sulphuretted ores, it is true, would be somewhat lessened by the fact that the fabric of the bags would be rapidly destroyed by sulphuric acid, etc; but even this difficulty might be obviated by washing the mixed gases and metallic vapors by conducting them into a brick chamber through which water in the form of rain is falling. The water from this chamber might be run off through caustic lime to remove soluble metallic salts. The ordinary blower working in the flues between the zinc furnaces and the bags would prevent any injury to the draught of the furnace.

A discussion of the various mechanical devices and combinations already in use in England and elsewhere for preventing or reducing the loss by volatilization at lead furnaces is not deemed necessary in this connection. The results of Von Patera's experiments† made on a small scale, and having in view the saving of argentiferous fume through chemical reagents and reactions, may yet be found to contain the germs of important technical applications. Especially may this be true of those obtained by the use of sulphydric acid whereby waste sulphurous acid may be converted into sulphur, and a complete saving of volatilized silver and lead compounds be effected.

* These figures are condensed from the elaborate tables in Watt's *Dictionary of Chemistry*.

† *Zeitschrift für Berg und Hüttenwesen*, 1854, 33.

NEWARK, DEL., December 23, 1870.

EVOLUTION, AS AFFECTING THE EARTH'S CRUST.

[A Lecture delivered at the Franklin Institute, December 8th, 1870,]

By Prof. Leeds.

Any one who has visited the lovely falls of Trenton, in the State of New York, will have noticed that the dark blue limestone over which the water falls at the bottom of the glen is filled with the remains of crustaceans and shells. There are multitudes of the tiny rings of crinoidal stems, and sometimes the entire flower-like body and branching arms of the lily encrinite; many species too, of those curious crab-like animals with great projecting eyes like horns, called Trilobites. Now, if any one of us, who chanced to be inclined to the study of nature, had passed his childhood among rocks so filled with fossils as these are, and at the same time so destitute of minerals, he would have turned conchologist. But the schoolboys who spend their holidays on the Schuylkill or Wissahickon, the Delaware, Crum Creek, Darby Creek, or the Brandywine, and hammer way upon every rock they meet, never encounter relic of fossil, bird, beast, fish, worm, or shell. They do, however, find minerals, in great abundance and in great variety. I made, some while since, a catalogue of the minerals native to South-eastern Pennsylvania, and found that it included more than one hundred well defined species. If to these the varieties be added, the number does not fall far short of two hundred. There is no large city in the country, New York, Boston, Baltimore, Cincinnati, Chicago, all being included, which possesses so rich a cabinet; one, too, that is accessible to every student, at all times, and free of cost. As a consequence, Philadelphia is, and always bas been, noted for its multitude of mineral collectors and fine mineral cabinets. The collections of Mr. Vaux, Mr. Clay and Mr. Trautwine are excelled by no private, and that of the first named gentleman by no public museum in the country. They contain a number of species which have first been recognized as such from specimens found in this vicinity. Nor is our neighborhood exhausted. A rich field still waits to be tilled by some one who will undertake the labor necessary to carry through the analysis of undetermined minerals to a successful conclusion. South-eastern Pennsylvania, then, is made up of mineral bearing, not fossil bearing rocks, and this is the first important point to which I wished to direct your attention.

The youth who commences his geological studies while rambling through the lovely valleys and over the gently sloping hillsides that encircle our native city, commences his geological studies as nature herself would dictate, were she to become articulate and constitute herself his teacher. The layers of rock, which, piled one upon another, make up the earth's surface, have been frequently and very aptly compared to a series of volumes: the layers which are deepest down, and which, as we shall presently see, were first formed, constituting the introductory books, and those lying near the surface the concluding ones. If the student wishes, then, to understand Geology, he must read these books as nature has written them, and begin with those which she wrote first. Now, one of the very earliest books is in the possession of the students who reside in Philadelphia. Of the second, third, fifth, and many of the later books, we possess but fragments, and must borrow them of our friends who live in New York State and New Jersey, and along the Gulf, if we desire to read them in full. From the first I propose to read, later in the course, some interesting extracts.

These books are written in what the student of general literature would be apt to call the *dead languages* of natural history, its Greek and Latin, so to speak. But there are as many beautiful poems and strange stories told in those dead languages by lips of stone, as Grecian poets sung, and as equally worthy of translation into speech intelligible to those who live at the present day.

The great fire at Alexandria, that burned the famous library, destroyed, it is said, many manuscripts which would have thrown light upon the early history of the Asiatic monarchies. Similar catastrophies, at the beginning of the world's geological history, destroyed a library as great as that which has been left to us. So few are the surviving fragments, that all the sagacity of science is required to re-write that history—and when re-written, it is almost too marvellous to admit of our belief. It tells of a time when the vital and spiritual forces had not yet been set into operation upon our planet—when, from pole to pole, and from peel to core, the earth was given over to the fierce conflict of physical and material powers—when, as yet, the rocks were fluid;—though ten years ago it would have been a rash assertion to make, yet in view of what the spectroscope has revealed to us concerning the constitution of the solar atmosphere, when some rocks were even gases—when these rocks were part, not of the earth, but of the air.

Strangely different, then and now, the earth's atmosphere. Instead of that soft and delicious fluid in which we are bathed, and from which, without labor and without cost, both plants and men drink in unconsciously the greater part of their food and physical energy; that sweet air, which the Greeks called ether, and the very name and thought of which has something poetically associated with it, an atmosphere existed then such as Milton imagined for Pandemonium. It was of vast extent, for the prodigious bulk of water which now constitutes the oceans then existed in the gaseous form, its components, oxygen and hydrogen, being as yet uncombined. In great probability, it contained the oxygen and sulphur, which are now locked up in the rock masses. For, although heat usually *assists* chemical union, yet when it exceeds a certain point, which differs for every substance, instead of assisting, heat *opposes* chemical union; in fact, it becomes the worst foe chemism or the chemical attraction between particles has to deal with. To take an example: if mercury be heated in contact with air to a temperature of 600° Fahrenheit, it takes up oxygen, and becomes coated with a rust, which is known as the red oxide of mercury. If this rust, on the other hand, be heated to a temperature of 750°, it is broken up and resolved once more into mercury and oxygen. If these were chemical lectures, it would be proper for me to state the very beautiful and satisfactory mode by which the modern chemistry explains such apparent anomalies, but we must content ourselves at the present time with a mere statement of the fact. Now, what happens to the red oxide of mercury at 750° happens to every oxide and sulphide at some certain temperature, whether it be 30° of the Fahrenheit scale or 3000°. I feel assured of the truth of this statement, not because I have tested it experimentally in the case of all, or indeed of very many, chemical compounds, but because it follows as a consequence, when certain principles which the modern chemistry regards as of great importance are admitted. Oxygen, hydrogen, nitrogen, sulphur, chlorine, iodine, bromine and the vapors of certain easily vaporisable metals, such as arsenic and tellurium, constituted our atmosphere. At that time it stretched away until it filled a large part of the space included within the orbit of the moon. And if the spectroscope reveals sodium, as existant in the state of vapor in the solar photosphere, why should not sodium, when the earth was in a condition of like fusion, have existed in the terrestrial atmosphere? If sodium, why not the similar metals,

potassium and lithium? The sun's photosphere, so says the spectroscope, contains iron gas, magnesium gas and calcium gas. We conclude then that these and many other metals, of similar density and volatility, once existed upon our globe in the gaseous form. They surrounded the earth's surface in a dense sulpurous atmosphere of appalling magnitude. Other substances, such as gold, platinum, and the noble metals generally, silicon and carbon, the latter of which can be converted into a liquid only at the most exalted temperatures, constituted the fluid body of the earth.

I shall ask you to accompany me one step further back into this dark and misty realm, and look upon the order in which these elements were arranged. This order was connected with a fact which strikes us first of all, when we examine the sixty-four elementary bodies of which the earth, in case its core be of the same composition as its crust, is known to consist. And that is, that some of these elements, such as hydrogen and potassium, are very light, others, like platinum and gold, very heavy, and between these extremes a long series, in which iron, cobalt, etc., occupy the middle position. Would this difference in weight have arranged the earth's surface in layers, and would all the hydrogen have floated at the top, all the nitrogen have formed a second layer, the oxygen a third, the sulphur a fourth, the sodium an eighth or ninth, the iron a thirtieth or thereabouts, and the platinum a fiftieth?

So far as these bodies were gases, undoubtedly not. For we have, to guide us in this matter, the analogy of the earth's atmosphere at the present time. It is composed, as all of you are well aware, principally of three gases, nitrogen, oxygen and carbonic acid. Though the second is considerable heavier than the first, and the carbonic acid much heavier than either of the other two, yet the boldest æronaut who has brought down air from regions where float the feathery cirrus clouds of summer skies, has never yet found a spot, however high, where the proportions in which these gases exist, mingled together in the earth's atmosphere, are not precisely the same as upon the earth's surface. This is due to the fact that the particles of gases are moving at all times in straight lines, with great velocity, and they go on until they meet with an obstacle capable of resisting their motion. In the present instance, one wall of their prison house is the earth's surface, the other is the invisible barrier presented by the force of gravitation.

The case was different with regard to those elements which ex-

isted in a molten state. For we know, that the lighter a liquid, the nearer it rises to the surface. I throw out these remarks, as suggesting the reason why the oxides of the lighter metals, such as silica, potash, water, magnesia, etc., should, at the present time, be found upon the earth's surface, while the oxides and sulphides of the heavier elements, such as lead, copper, etc., should have accumulated far below, and have been shoved through cracks and fissures to the surface.

This liquid mass and the huge envelope of gas and vapors that surrounded it, obeyed the same planetary laws of motion then as now. It swept onward through similar realms of space. Astronomy teaches us that these stellar regions are intensely cold. Their temperature is as far below the zero point of our Fahrenheit scale as our mean summer temperature rises above it. And if the earth's atmosphere were swollen with all the ingredients that I have before mentioned, its radiatory surface was of vast area, and the process of cooling went on with great rapidity. There was a time for every element when it reached that critical point in its history of which I have spoken. It cooled down so far that it could enter into combination with oxygen or sulphur, with chlorine, iodine, or whatever element it possessed the greatest attraction for. As soon as these compounds were formed they were precipitated by their weight upon the earth's surface.

(To be continued.)

THE SUN.

(A course of five lectures before the Peabody Institute of Baltimore, January, 1870.)

By B. A. Gould.

(Continued from page 71.)

I must recur, before long, to the consideration of the spots; for upon the careful observation of these, a large share of our knowledge of the sun's constitution must depend. There is much to be said concerning their motions, real and apparent, their origin, development, recurrence, &c.; but it seems better first to complete the general description of the sun's aspect, deferring for a while these more detailed points. There is, however, one important fact which must be mentioned here, viz: that the spots are not found on all parts of the sun indiscriminately, but are, with very few exceptions,

restricted to two belts, one on each side of the sun's equator, extending from about 8° to less than 40° of solar latitude, their most frequent occurrence being at the latitude of 20°. Spots are sometimes seen beyond these limits, but well authenticated cases are extremely rare, and the zones within which they are ordinarily to be seen scarcely comprise an area of one half of the sun's surface. We know, as I have mentioned, and will hereafter explain, that the sun rotates on his axis, like the earth and other planets, and in the same direction. Johannes Fabricius, the first discoverer of the spots, found out this fact also, which had previously been suspected from analogy. The axis of rotation is, according to the best determinations yet made, inclined to the plane of the earth's orbit by $7\frac{1}{4}°$. Did the earth's revolution take place on the same plane as the sun's equator, the spots would appear to be carried, by his rotation, in parallel straight lines across his disk, from left to right. This is indeed the case during the second weeks of June and September, at which times the earth is in that plane; but at other seasons the lines of their apparent motion appear elliptical, in consequence of the effect of perspective upon circles inclined to the line of vision.

Of the faculæ, or patches brighter than the general surface, I have already mentioned the chief characteristics. These bright spots were noted both by Scheiner and by Galileo; and although less attention has been given to their study, and indeed less opportunity for it has existed, than has been the case for the spots, some facts are well established. Though usually elongated and narrow, not only near the middle of the disk as scars, but also in the vicinity of spots, they are by no means always so, but frequently exhibit the most irregular and fantastic forms. There is one class of them which are comparatively small, but well rounded; others are reticulated, and others still have been compared to grotesque attenuated human figures. That they may generally be found near the margins of spots, and especially on that side from which the spots appear to be moving by virtue of the sun's rotation, has been stated; and also that the converse of this statement does not hold good, since faculæ are often seen where no tokens of spots are to be detected. They are not restricted to the equatorial belts in which the latter are in general only to be seen, but may be found at all parts of the surface, although certainly unfrequent near the poles, and most abundant in the spot-zones. Their greater distinctness in the

0 10 20 30 40 50 60

1" on drawings = 027 inch.
1" on the Sun = 449 miles.

N

Fig. 1.

Fig. 2.

W

E

S

Fig. 3.

N W E S

Oct. 12th. 9h. 30m A.M.

neighborhood of the sun's limb, where his light is much dimmer, suggested long ago, that they might be elevations; and the stereoscope, used in the manner already described, exhibits them as floating above the photosphere like clouds. Indeed, there can be little, if any doubt that they are elevated above the general surface, and they have been seen actually to project at the sun's margin like mountains.* Yet, although they gain in relative brightness, as compared with the background, in proportion as they are nearer to the limb, Winnecke, a most trustworthy authority, says† that after they have reached a very close proximity to the border, they, too, fade away like the general surface of the sun in the same position. The photograph of the sun, already exhibited, will have given some idea of the appearance of these objects. Their dimensions vary as greatly as those of the spots. One faculæ observed‡ by Herschel was $2\frac{3}{4}'$ long, which corresponded to a real length of 74,000 miles, being more than nine times the diameter of our earth.

A curious and frequent appearance is that of the so-called "bridges," which often cross a spot dividing it like partitions. Sometimes these are intensely brilliant, crossing penumbra as well as nucleus, while in other cases they are no brighter than the penumbra, and only perceptible when in contrast with the dark nucleus. These bridges are of such frequent occurrence that it is evident they are characteristic phenomena; and no explanation of the spots, or of the nature of the sun, can be deemed adequate which fails to account for them. Both their formation and their disappearance have been frequently observed; tongues of light are seen darting across from one side, or from both sides toward each other, until a bridge is established, in a way not unlike that which naturalists describe when microscopic organic forces are in process of development; and again they are seen to fade gradually away, growing fainter and fainter, until from an intense brightness they have seemed to dissolve and disappear. One of these is shown in Fig. 3 of the accompanying Plate, copied from a drawing, by Mr. Haslett, of a spot seen in October, 1866.

Such are the appearances to be observed with a telescope of moderate power, say with one magnifying not more than one hundred times, and with an object-glass of not more than five inches in di-

* *Monthly Notes R. Astr. Soc.* XX, 56; XXIII, 13, 110; XXIV, 55.

† *Die Sonne*, p. 23.

‡ 1800, Dec. 3, Herschel's measures gave 2′ 45.9″.

ameter. But when larger instruments and higher powers are brought to bear—with good defining capacity, and solar eye-pieces which protect the eye without confusing the delicate details of the image—a new series of phenomena is revealed, and one of the greatest importance for guiding to a knowledge of the sun's true structure.

So long ago as Scheiner's time, the mottled or corrugated aspect of the sun's disk was seen to be due to irregular and very narrow streaks of light. Scheiner himself had observed them, and discoursed upon them in his great work on the solar spots, the "*Rosa Ursina*." Herschel found* that the darker intermediate portions were dotted with small points as black as the nuclei of spots. These points, or pores, as they are often called, appear, in general, nearly round, and are dotted in countless numbers over every part of the surface. They seem to be undergoing continual change, so that an individual point, the position of which is accurately noted at one instant, is at the next moment not to be found; or, in other cases, may have expanded and formed itself into a little round spot without penumbra, such as exist in large numbers, and may almost always be found, on careful scrutiny, in the vicinity of large spots. Indeed, the large spots are not unfrequently developed from groups of these small ones. But Dawes, a conscientious and careful English observer, thinks† that the varying aspect of the pores is due to slight atmospheric fluctuations which bewilder the sight, when the object under examination is so minute. And he says, too, that these points, or pores, have to him the aspect of very small fissures or short dark lines, and are rather gray than black.

About the year 1863, Mr. Nasmyth, of Manchester, the celebrated inventor of the steam hammer, announced‡ the discovery that, with a powerful telescope of sharp defining power, and under favorable atmospheric conditions, the whole luminous surface of the sun appeared to consist of a thin layer of bright filaments, shaped like willow leaves, averaging about 1000 miles in length and about 100 in breadth; that these lay scattered over the sun generally in every variety of direction, across each other; and that the black points were simply the interstices between the willow leaf filaments. This announcement stimulated at once to very minute scrutiny of the face of

* *Phil. Trans.* 1802, p. 294.

† *Monthly Notices R. Astr. Soc.* XXIV, 35.

‡ *Ibid.* XXIV, 66.

the sun, and to an active controversy among the observers. All agreed that the luminous surface was composed of bright particles, but Nasmyth's description found but little confirmation. One observer proposed the term "rice-grains" as better representing the form of the objects in question; another preferred the word granulations; a third compared them to beach gravel; and a fourth considered *crystals* as the proper term. Many stated that these luminous particles had long been well known to them; but all agreed that they bore small resemblance to willow leaves, and indeed Mr. Nasmyth subsequently modified his original statement by assorting the granules in four classes, one of which was the willow leaf. Huggins, Dawes, Chacornac, Stone and others have observed and written much upon the subject, and the general facts established seem to be essentially those which have been very clearly set forth by Mr. Huggins, of London.*

(To be continued.)

PRELIMINARY REPORTS FROM THE U. S. ECLIPSE PARTIES.

It is yet too early to learn the full results of the observations of the eclipse of 22d December, made by the American observers. Enough, however, has been received to assure us of a very varied fortune experienced in the several localities chosen. The following is the substance of the preliminary reports made by the Naval Professors to Commodore Sands, Superintendent of the U. S. Naval Observatory.

Prof. Hale, by letter of 22d from Syracuse, reports "That the four contacts were pretty well observed. During the total eclipse, thin clouds covered the Moon, making, I think, the physical observation somewhat doubtful. The protuberances were very well seen. They were of a pale red color, and not so bright as I expected them to be. The clouds interfered with my observations of the Corona; I could detect but very little of the radiating and curved streamers given in so many pictures, and the slight radiation that I saw might have been produced by the clouds."

"I need hardly say that the total eclipse was a beautiful sight."

Prof. Harkness writes from Catania, Sicily: "Our latitude and longitude observations together with the necessary triangulation to connect our observing stations in the north bastion at the Prima

* *Monthly Notices R. Astr. Soc.* XXVI, 260.

Porta Tessa with the principal buildings in the city, were completed some days before the eclipse. Observations were also made to determine azimuth and magnetic variation. Up to December 20 the weather was very fine; on that day the barometer fell and the sky became cloudy. On the 21st and 22d, however, excellent observations for time were made, and our operations for the eclipse were complete. At its beginning the sky near the Sun was perfectly clear. The first contact was observed at 11 hours, 35 minutes, 27·5 seconds. As the eclipse advanced, the bright line was looked for, which was shown in such a marked manner along the edge of the Moon's limb in the photographs taken at Des Moines last year; but no trace of it could be seen till 12 hours, 8 minutes, when I thought I perceived it.

"Fifteen minutes before totality a dense cloud hid the Sun entirely. The wind was blowing with a force of from 3 to 5; so that the telescope, though sheltered by the parapet of the bastion, was steady, and the lanterns could not be lit near it.

"Within five minutes of totality, the cloud over the Sun fast became less dense. Presently, a thin crescent was all that remained of the Sun, and this dwindled rapidly away, so that at 1 hour 11 seconds I observed the commencement of totality with the naked eye. The cloud was sufficiently thin to allow the Corona to be seen, but diminished in extent and brilliancy, appearing scarcely more than two-thirds as large as that seen in Des Moines.

"With an Arago polariscope in hand the first ten seconds were spent in observing that the sky was polarized all around the Corona, while the Corona itself showed no trace of polarization. Springing to the spectroscope, I saw the green line of which I found the reading to be about the same with that of 1869. The spectroscope directed to many different parts of the Corona by my friend Captain Tupman, R. M. A., showed the same green line.

"During the last few seconds of the totality, the thin cloud covering the Sun became nearly dissipated, and the faint continuous spectrum of the Corona became visible. I could not believe that the eclipse had lasted, according to the chronometer (Negus' of New York), one hundred and fifteen seconds; it seemed a moment only.

"I think that our observations, though made at disadvantage by the high wind and the thin cloud, prove beyond question that the Corona does belong to the Sun; that it is to a great degree, if not entirely, self-luminous, and that its light gives a green line at about

1,474 divisions of Kirchhoff's scale. The observations by the polariscope go to prove that the light from the Corona is not polarized. Five minutes after the totality was over the sky became perfectly clear. The last contact was at 2 hours 19 minutes by the chronometer, which was, approximately, 1 hour 2 minutes 45 seconds slow of Syracuse local mean time."

Prof. Newcomb reports from Gibralter yet more favorably.

"I had chosen a position more than a mile from the town near the southern end of the rock, because the authorities have all agreed that a '*Levanter*' would cover the rock with fog, though it might be clear, both to the north and south. An hour before the eclipse commenced, it rained so hard that I had to cover my instruments; in a half-hour more, the straits were covered with clouds and mists with hardly a patch of sky to be seen except in the north, but 20 minutes later the clouds moved north, leaving some thin places through which the Sun was seen at intervals. I succeeded in observing the first contact which did not occur till about 25 seconds later than the time predicted by Hansen's tables in the British Nautical Almanac, but very near the time of the American Ephemeris. During the intervals in which I could see the Sun, using the lightest shade, I succeeded very well in obtaining transits of the cusps for determining the direction of the centre of shadow.

"I got the commencement of totality very well. During the total phase, the clouds thinned out enough to give a view of the Corona and the protuberances through the flying scud. The observations to which I had intended to devote the two minutes of totality, had reference to the physical appearance of the phenomenon; its form and dimensions, the relative brilliancy of its parts and its apparent structure. I desired to note especially whether it seemed nebulous or whether its light seemed soft and uniform. The clouds, however, prevented my seeing more than this, that the light was perfectly soft and milky without any appearance of cloudiness. The striation so frequently described by observers was certainly not there. There was nothing whatever in the shape of rays to be seen through the scud. The protuberances were very numerous and much more brilliant than the Corona, exhibiting the numerous fantastic shapes shown in the photographs of the last eclipse. Their redness was very brilliant indeed The most noticeable rose up from the Moon like a horn. The darkness was even less than I

expected, as I could read the face of the chronometer within my tent without difficulty.

"During the half hour following the total phase I obtained very good transits of the cusps, and near the end of the eclipse, measures of the distance of the cusps." Altogether the observations may be regarded as successful.

From Prof. Eastman, who had charge chiefly of the Meteorological Observations no report has as yet been received. It will be seen that the impressions given by the floating notices in the newspapers have been unnecessarily discouraging.

The naval professors have not as yet returned to the United States, being engaged under the instructions from the Observatory in visiting and inspecting closely the chief European observatories. The utmost courtesy has been extended to them by the Royal Astronomer, the Radcliffe observer and Mr. Newall, the proprietor of the splendid telescope at Gateshead, and others. Drawings of that telescope (25-inch object glass) have been made by Mr. Newall and forwarded to Commander Sands.

The same courtesy from Sir James Anderson and Mr. Culley, Superintendent of the Government Telegraph, placed the land wires and the Falmouth, Malta and Gibralter Cable at the use of the professors for determining by time signals the longitude of Gibralter, Malta, Catania and Syracuse; and tendered a passage to Gibralter in H. B. M. S. "The Urgent." At Gibralter and Syracuse the Italian authorities offered every facility.

At Augusta, Sicily, they had the pleasure of meeting with a large party of Italian and English astronomers, Father Secchi being one of the company.

We learn from private letters some items of the varying fortunes of other observers. Prof. Peirce, of the United States Coast Survey, and Prof. Watson, of the Michigan University, are reported to have succeeded in getting full views of the totality, at a station happily chosen a few miles out of Syracuse. By a reverse of fortune Prof. Peters, of Hamilton College, so renowned for his discoveries of asteroids, missed the phenomenon, owing to a furious snowstorm at Mount Etna. It is possible that a good view was obtained by parties higher up. But Prof. Hall writes that an English party went up some 5,000 feet, but were in the storm the whole of the totality.

Gen. Abbott, of the U. S. Army, saw nothing though he went up still higher. Prof. Watson had a clear sky. He went down to Carlentini near the central line and had a full view.

The worst fate seems to have attended the English and French parties who crossed the Straits. Those at Oran had a furious storm around them. M. Janssen, so successful in the eclipse of 1868, saw nothing. He had come out of Paris in a balloon to observe the phenomenon.

Bibliographical Notices.

The Kansas City Bridge. By O. Chanute, Chf. Eng., and George Morrison, Asst. Eng. Illustrated. D. Van Nostrand, N. York.—Following the example of Mr. T. C. Clarke, Messrs. Chanute and Morrison have produced a valuable addition to that class of professional literature which has for its object the simple record of executed works.

It is a pity that so few such books are published, the theoretical side of the question having had almost the sole attention from writers, until there is very little more to be said. An engineer who takes the trouble and pains to relate the practical difficulties under which certain works were carried on, and how these difficulties were successfully met, deserves the thanks of his professional brethren.

In the volume before us, Messrs. Chanute and Morrison have given a detailed description of the Kansas City Bridge, embracing the history of the project, and character of the work in relation to the hydrography of the Missouri river. By far the most interesting feature to the engineer is that of the foundations, which involved difficulties hitherto unprecedented in the annals of American engineering. How these difficulties arose, were met, and conquered, are detailed at great length, and amply illustrated by scale drawings. This chapter is one of great interest and of positive value, since the problem of economically founding masonry in deep water, amid shifting sands and rapid currents, is perhaps the most difficult one with which an engineer has to deal. In regard to the superstructure, there is nothing particularly new, the principal feature being the great draw span of 360 feet, designed and built by the

Keystone Bridge Company of Pittsburg. The draw is wholly of iron, while the permanent spans are a combination of wood and iron, all compressive members being wood, and the tension of iron. Why any wood was used at all in a work of the magnitude of the Kansas City Bridge, we are at a loss to see, as we believe the economy which must have dictated its use to be more fancied than real.

The draw span is open to considerable criticism, since it has been proportioned when closed, as if there were two independent spans on either side of pivot, no reference being had to the continuity that really exists at that point. The necessity for regarding the draw as a beam, supported in the middle, is very apparent, from the fact that a train upon one arm "has caused the further end to rise seven-eighths of an inch." The wedge blocks under the free ends, intended to give a bearing when the draw is closed, have so little lifting power that almost the whole weight continues to be carried by the pivot pier. Mr. Chanute proposes to remedy this error of design by introducing hydraulic jacks under the end posts, by which means sufficient lifting power can be brought into action, and it is to be hoped will in a great measure cause the actual strains to conform to those calculated. The problem of a self-sustaining draw is one of considerable nicety, and perhaps in this country has not received the analytical consideration to which it is entitled. All of the great draws of which we have any knowledge have been computed in precisely the same manner as that of the Kansas City Bridge. Messrs. Chanute and Morrison have candidly called attention to this fact, and they have, moreover, gone mathematically into the question, resulting in a determination to replace the "wedges" by "jacks," as above remarked.

The wisdom of making a draw "self-sustaining" is open to considerable discussion. Except in very great spans, we think the gallows frame draw has superior advantages. Although less pleasing in appearance, the gallows frame is cheaper, easily adjusted, and needs no complicated lifting appliances under the free ends. When a span is large, the expense and inconvenience of carrying up high towers may be easily gotten over by attaching the chains to a point, say a quarter or half span in length from the free ends, in which case the part of the truss beyond the point of support must be made self-sustaining. Such construction has by no means a poor effect, and results in a marked saving for those who have to pay for it, over what would be required for a properly proportioned self-sustaining draw bridge.

Messrs. Chanute and Morrison deserve the thanks of their professional brethren for their contribution to the literature of practical engineering, and their well doing has been creditably seconded by their publisher, Mr. Van Nostrand, who has exercised as much good taste in the manner of the publication as the writers have in their matter. We have no doubt that the book will be rewarded with the large sale it deserves. A. P. B.

On the Hypothesis of Evolution: Physical and Metaphysical. By Prof. Edward D. Cope, New Haven, Conn.: Charles C. Chatfield & Co. 1870.

The coldness and disfavor with which the doctrine of development is still received with us is in remarkable contrast with its enthusiastic reception, and almost universal ascendency in the schools abroad. As to the causes of this state of things, a variety of opinions may be urged; but there can be but one, concerning the value of a clear, philosophical review of this most interesting field of modern science. A review of this character we have in the work before us, a fact which the acknowledged ability of its learned author would fully assure.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, November 16th, 1870.

The meeting was called to order by the President, Mr. Coleman Sellers, in the chair. The minutes of the last meeting were read and approved.

The Actuary submitted the report of the Board of Managers, and reported that at the stated meeting held November 9th, donations were received from the Royal Astronomical Society; The Society of Arts, London, and the Steam Users' Association, of Manchester, England.

The report of the Secretary upon Novelties in Science and the Mechanic Arts, was then read, upon which it was announced that the following gentlemen:—Prof. Henry Morton, J. Blodget Britton,